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Chaves GSS, Freitas DA, Santino TA, Nogueira PAMS, Fregonezi GAF, Mendonça KMPP

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[Intervention Review]

Chest physiotherapy for pneumonia in children

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ABSTRACT

Background

Pneumonia is a lung infection that causes more deaths in children aged under five years than any other single cause. Chest physiotherapy is widely used as adjuvant treatment for pneumonia. Physiotherapy is thought to help remove inflammatory exudates, tracheobronchial secretions, and airway obstructions, and reduce airway resistance to improve breathing and enhance gas exchange. This is an update of a review published in 2013.

Objectives

To assess the effectiveness of chest physiotherapy with regard to time until clinical resolution in children (from birth to 18 years) of either gender with any type of pneumonia.

Search methods

We searched the Cochrane Central Register of Controlled Trials (CENTRAL; 2018, Issue 1), which includes the Cochrane Acute Respiratory Infections Group Specialised Register, MEDLINE (22 February 2018), Embase (22 February 2018), CINAHL (22 February 2018), LILACS (22 February 2018), Web of Science (22 February 2018), and PEDro (22 February 2018). We also searched clinical trials registers (ClinicalTrials.gov and WHO ICTRP) to identify planned, ongoing, and unpublished trials.

Selection criteria

We included randomised controlled trials (RCTs) that compared any type of chest physiotherapy with no chest physiotherapy for children with pneumonia.

Data collection and analysis

We used standard Cochrane methodological procedures. The primary outcomes of interest were mortality, duration of hospital stay, and time to clinical resolution. We used Review Manager 5 software to analyse data and GRADE to assess the quality of the evidence for each outcome.

Main results

We included three new RCTs for this update, for a total of six included RCTs involving 559 children aged from 29 days to 12 years with pneumonia who were treated as inpatients. Pneumonia severity was described as moderate in one trial, severe in two trials, and was not

stated in three trials. The studies assessed five different interventions: effects of conventional chest physiotherapy (3 studies, 211 children), positive expiratory pressure (1 study, 72 children), continuous positive airway pressure (CPAP) (1 study, 94 children), bubble CPAP (bCPAP) (1 study, 225 children), and assisted autogenic drainage (1 studies, 29 children). The included studies were conducted in Bangladesh, Brazil, China, Egypt, and South Africa. The studies were overall at low risk of bias. Blinding of participants was not possible in most studies, but we considered that the outcomes were unlikely to be influenced by the lack of blinding.

One study of bCPAP reported that three deaths occurred in children in the physiotherapy group (N = 79), and 20 deaths in the control group (N = 146) (risk ratio (RR) 0.28, 95% confidence interval (CI) 0.08 to 0.90; 225 children; low-quality evidence). One study of assisted autogenic drainage (N = 29), and one study of conventional chest physiotherapy (N = 72) reported no deaths occurred. It is uncertain whether chest physiotherapy techniques (bCPAP, assisted autogenic drainage, and conventional chest physiotherapy) reduced hospital stay duration (days) (mean difference (MD) 0.10, 95% CI -0.56 to 0.76; 4 studies; low-quality evidence).

There was variation among clinical parameters used to define clinical resolution. Two small studies found no difference in resolution of fever between children in the physiotherapy (conventional chest physiotherapy and assisted autogenic drainage) and control groups. Of five studies that considered peripheral oxygen saturation levels, only two reported that use of chest physiotherapy (CPAP and conventional chest physiotherapy) showed a greater improvement in peripheral oxygen saturation levels. However, it was unclear whether respiratory rate (breaths/min) improved after conventional chest physiotherapy (MD -2.25, 95% CI -5.17 to 0.68; 2 studies, 122 children; low-quality evidence). Two studies assessed adverse events (number of events), but only one study reported any events (RR 1.28, 95% CI 0.98 to 1.67; 2 studies, 254 children; low-quality evidence).

Authors' conclusions

We could draw no reliable conclusions concerning the use of chest physiotherapy for children with pneumonia due to the small number of included trials with differing study characteristics and statistical presentation of data. Future studies should consider the following key points: appropriate sample size with adequate power to detect expected differences, standardisation of chest physiotherapy techniques, appropriate outcomes (such as duration of leukocytosis, and airway clearance), and adverse effects.

PLAIN LANGUAGE SUMMARY

Chest physiotherapy for pneumonia in children

Review question

We reviewed the evidence regarding the effect of any type of chest physiotherapy for children with pneumonia.

Background

Pneumonia is a type of lung infection and the biggest cause of worldwide deaths among children aged up to five years. Chest physiotherapy may contribute to children's recovery because it can help to open airways and assist breathing.

Search date

The evidence is current to 22 February 2018.

Study characteristics

We included six studies involving 559 children with pneumonia aged from 29 days to 12 years. This is an update of a review published in 2013 and includes three new studies.

Studies were conducted in hospitals in Bangladesh, Brazil, China, Egypt, and South Africa.

Pneumonia was described as moderate to severe in three studies, but severity was not described in three studies. All studies included children who received physiotherapy and others who did not. All children also received standard medical treatment for pneumonia.

The studies assessed deaths, length of hospital stay, time taken to attain normal test results (no signs of pneumonia), and adverse events.

Study funding sources

Four studies reported sources of funding (a child health agency, university, government research grants), and two did not report study funding sources.

Key results

One study reported fewer deaths in children who received bubble continuous positive airway pressure (bCPAP). Physiotherapy techniques (bCPAP, assisted autogenic drainage, and conventional chest physiotherapy) were not associated with shorter hospital stays. Two studies reported improvements in blood oxygen levels after chest physiotherapy (CPAP and conventional chest physiotherapy). No clear

improvement in respiratory rate was observed after conventional chest physiotherapy. Based on the available evidence, we could not confirm if chest physiotherapy is beneficial or not for children with pneumonia.

Quality of the evidence

We assessed the overall quality of the evidence as low due to inadequate study methods and design, differing results among studies, and few data.

Summary of findings for the main comparison. Chest physiotherapy compared to no chest physiotherapy for pneumonia in children

Chest physiotherapy compared to no chest physiotherapy for pneumonia in children

Patient or population: children aged from 29 days to 12 years with pneumonia
Setting: hospitals in Egypt, Bangladesh, South Africa, Brazil, and China
Intervention: conventional chest physiotherapy, positive expiratory pressure, CPAP, bCPAP, assisted autogenic drainage
Comparison: no physiotherapy

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Quality of the evidence (GRADE)	Comments
	Risk with no chest physiotherapy	Risk with chest physiotherapy				
Mortality (follow-up: 1 to 21 months)	**Study population**		**RR 0.28** (0.08 to 0.90)	225 (1 RCT)	⊕⊕⊖⊖ LOW [1]	One study reported 3 deaths with bCPAP (N = 79) and 20 deaths in the control group (N = 146). One study of assisted autogenic drainage (N = 29) and one study of conventional chest physiotherapy (N = 72) reported no deaths occurred • Settings: hospitals in lower-middle-income and upper-middle-income countries (Bangladesh, South Africa, and Brazil)
	137 per 1000	38 per 1000 (11 to 123)				
Duration of hospital stay (days) (follow-up: days)**	The mean number of days was 5.9.	MD 0.1 higher (0.56 lower to 0.76 higher)	**MD 0.10** (-0.56 to 0.76)	415 (4 RCTs)	⊕⊕⊖⊖ LOW [2, 3]	We conducted a post hoc sensitivity analysis by removing the instrumental technique, the heterogeneity increases from 1% to 49%. We conducted a subgroup analysis by techniques (conventional, modern, and instrumental). No difference was found between subgroups (P = 0.24). • Interventions: bCPAP, assisted autogenic drainage, and conventional chest physiotherapy • Settings: hospitals in lower-middle-income and upper-middle-income countries (Bangladesh, South Africa, and Brazil)
Time to clinical resolution (all parameters)	2 small studies found no difference in resolution of fever between children in the physiotherapy and control groups.			559 (6 RCTs)	⊕⊕⊖⊖ LOW [2, 4]	We reported outcome results narratively because the included studies considered different parameters to evaluate time to clinical resolution.

(follow-up: days)**	2 out of 5 included studies reported a greater improvement in peripheral oxygen saturation levels. Meta-analysis of 2 studies shows no significant improvement of respiratory rate (MD -2.25, 95% CI -5.17 to 0.68).					• Interventions: conventional chest physiotherapy, bCPAP, assisted autogenic drainage, and CPAP • Settings: hospitals in lower-middle-income and upper-middle-income countries (Egypt, Bangladesh, South Africa, Brazil, and China)
Adverse events (number of events) (follow-up: 1 to 21 months)	**Study population**		**RR 1.28** (0.98 to 1.67)	254 (2 RCTs)	⊕⊕⊖⊖ LOW[5]	1 study reported that no adverse events had occurred. • Interventions: assisted autogenic drainage and bCPAP • Settings: hospitals in lower-middle-income and upper-middle-income countries (South Africa and Bangladesh)
	404 per 1000	517 per 1000 (396 to 674)				

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the __relative effect__ of the intervention (and its 95% CI).

**The studies considered follow-up as the number of days to discharge.
__bCPAP:__ bubble continuous positive airway pressure; __CI:__ confidence interval; __CPAP:__ continuous positive airway pressure; __MD:__ mean difference; __RCT:__ randomised controlled trial; __RR:__ risk ratio

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of the effect.
Moderate quality: We are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low quality: Our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low quality: We have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

[1]Downgraded two levels for imprecision due to the low number of events occurring in only one study.
[2]Downgraded one level for risk of bias. One study was at high risk for selective reporting.
[3]Downgraded one level for imprecision. The upper confidence limit crosses an effect size of 0.5 in either direction.
[4]Downgraded one level for inconsistency. Variation in the reporting of the outcome.
[5]Downgraded two levels for imprecision. The total sample size was < 400 (a threshold rule-of-thumb value suggested by the GRADE Working Group).

BACKGROUND

Description of the condition

Pneumonia is the single-biggest cause of death in children and was responsible for the deaths of 920,136 children aged up to five years in 2015. It accounted for 16% of all causes of deaths in this population, most of which were preventable (WHO 2016; Zar 2014).

Community-acquired pneumonia is common among children globally, but incidence and mortality rates are significantly higher in low-income countries (Principi 2011). Hospital-acquired pneumonia and ventilator-associated pneumonia are the second most common hospital-acquired infections (Rotstein 2008).

Pneumonia is inflammation of the lungs and fluid collection in the alveoli (Oliveira 2011; Zhang 2012). The two most common organisms responsible for pneumonia in low-income countries are *Streptococcus pneumoniae* and *Haemophilus influenzae* (Dagan 2011; Gilani 2012). Children with pneumonia are treated with antibiotics, with hospitalisation and oxygen supplementation required in some cases, depending on disease severity (Scott 2012).

Accumulation of secretions in the airways due to respiratory infection contributes to the worsening of clinical symptoms and leads to an increase in airway resistance with each breath (Durbin 2008). Signs and symptoms that are useful in diagnosing pneumonia are fever, tachypnoea, nasal flaring, cough, breathlessness, lower chest wall indrawing, and reduced oxygen saturation (Bradley 2011; Ebell 2010; Scott 2012). The gold standard for diagnosing pneumonia according to clinical guidelines is the presence of lung infiltrates indicated by chest radiography (Evertsen 2010).

Description of the intervention

Chest physiotherapy is an important adjuvant in the treatment of most respiratory illnesses (Balachandran 2005), and is used for children with chronic respiratory or neuromuscular disease (Gajdos 2010). The central aim of chest physiotherapy for children is to assist clearance of tracheobronchial secretions, thereby decreasing airway resistance, improving gas exchange, and making breathing easier (Gajdos 2010). However, it is important to consider children's specific respiratory system features. The mechanical principles of physiotherapy techniques applied for children are similar to adults. Nevertheless, there are changes in respiratory structure and function from birth to adulthood that require continuous adaptation in the application of the chest physiotherapy techniques according to age (Oberwaldner 2000). Those characteristics limit or even contraindicate the use of some physiotherapy techniques (Oberwaldner 2000).

Despite improving the child's respiratory status and expediting recovery, in certain situations physiotherapy may not be useful, or may even be harmful, increasing bronchospasm, inducing pulmonary hypertension, repositioning foreign bodies, or destabilising a sick infant (Wallis 1999). However, some chest physiotherapy techniques have been developed for use exclusively in children (Postiaux 1997).

Chest physiotherapy techniques can be classified as conventional, modern, and instrumental techniques (Morrison 2017; Yang 2013). Postural drainage, vibration, percussion, huffing and coughing, and thoracic squeezing are conventional techniques that aim to facilitate mucociliary clearance (Flude 2012; Main 2005; Yang 2013; Yousefnia-Darzi 2016). Conventional chest physiotherapy can be self administered or performed with the assistance of another person (a physiotherapist, parent, or caregiver), for example when performing those techniques that involve manual handling, such as manual vibration, thoracic squeezing, and percussion (Main 2005).

Modern techniques use variation of flow through breath control to mobilise secretions. Techniques include forced expiration, active cycle of breathing, autogenic drainage, assisted autogenic drainage, slow and prolonged expiration, increased expiratory flow, total slow expiration with the glottis open in a lateral posture, and inspiratory controlled flow exercises (Button 2013; Main 2005; Mckoy 2016; Mucciollo 2008; Postiaux 1997; Postiaux 2000; Yang 2013).

Instrumental techniques, such as non-invasive ventilation, have been considered useful as adjunct therapy to airway clearance (Button 2016; Holland 2003), and to provide respiratory support (Hansmann 2017). Non-invasive ventilation has been shown to produce favourable outcomes in people with respiratory distress (Baudouin 2002; Gosselink 2008). A common instrumental technique is continuous positive airway pressure (CPAP). Continuous positive airway pressure can be provided conventionally or as bubble CPAP (bCPAP) (Machen 2015), by providing gentle air pressure to keep the airways open (WHO 2016). Bubble continuous positive airway pressure differs from CPAP in that it uses an underwater system that generates 'bubbles' by submerging the expiratory tube (Martin 2014; Poli 2015). Continuous positive airway pressure is an effective tool to treat children, including preterm and low-birthweight infants, in respiratory distress (Kawaza 2014). Experience with treating respiratory distress in neonates suggests that bCPAP may be a very effective treatment for severe pneumonia in children (Shann 2015). In bCPAP, positive pressure support is provided for preterm infants from birth and during the acute stages of respiratory distress (Machen 2015). Incentive spirometry, positive expiratory pressure, and flutter are other tools that can be used to increase lung expansion and improve gas exchange (Britto 2014; Restrepo 2011).

Chest physiotherapy techniques are described in Appendix 1.

How the intervention might work

Chest physiotherapy involves the therapeutic application of mechanical interventions based on respiratory physiology (Oberwaldner 2000). Some techniques use body position to improve mucociliary clearance, re-expansion, and pulmonary ventilation (Alcoforado 2011). Other techniques use variation of flow through breath control, Mckoy 2016; Yang 2013, or devices to maintain airway clearance and improve ventilation by keeping the airways open during expiration (Yang 2013).

In bCPAP, pressure is safely regulated by submerging the end of the tubing in a bottle of water. The water depth determines the pressure in the system. The pressure helps recruit alveoli and increase functional residual lung capacity (Kawaza 2014).

The process of airway clearance in autogenic drainage is applicable only to children aged over eight years, and is based on an active or passive assisted autogenic drainage modulation of the airflow and lung volume-based level of breathing (Button 2013). Assisted autogenic drainage is a modified form of autogenic drainage that

is used for babies and young children because it does not require active participation (Corten 2017b).

The thoracic squeezing technique, or manually assisted coughing, includes manual compression of the thorax during expiration and pausing at the end of expiration to help the movement of pulmonary secretions, facilitate active inhalation, and enhance alveolar ventilation. The rationale of this technique is based on its compressive effect on the airways, increasing the airflow velocity, which increases mucus transport (Yousefnia-Darzi 2016).

The benefits of chest physiotherapy include evacuating inflammatory exudates and tracheobronchial secretions, removing airway obstructions, reducing airway resistance, enhancing gas exchange, and reducing the work of breathing (Roqué i Figuls 2016; Wallis 1999; Yang 2013).

Why it is important to do this review

Most childhood deaths caused by pneumonia could be avoided if effective interventions were implemented on a broad scale for the most vulnerable populations (WHOSIS 2011). Chest physiotherapy is widely used, although its use remains controversial (Balachandran 2005; Wallis 1999).

This Cochrane Review was first published in 2013 (Chaves 2013). This update aimed to incorporate the most recent study data and to reassess the effectiveness of chest physiotherapy for children with pneumonia.

OBJECTIVES

To assess the effectiveness of chest physiotherapy with regard to time until clinical resolution in children (from birth to 18 years) of either gender with any type of pneumonia.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs), cluster-RCTs or quasi-RCTs.

Types of participants

Children (from birth up to 18 years old) of either gender with any type of pneumonia.

Types of interventions

Chest physiotherapy of any type compared with no chest physiotherapy.

Types of outcome measures

Primary outcomes

1. Mortality.
2. Duration of hospital stay (days).
3. Time to clinical resolution (days) of any of the following clinical parameters: fever, increase of respiratory work (chest indrawing, nasal flaring, tachypnoea, respiratory rate), and peripheral oxygen saturation levels.

Secondary outcomes

1. Change in adventitious sounds.
2. Change in chest x-ray.
3. Duration in days of antibiotic therapy, cough and sputum production.
4. Duration in days of leukocytosis.
5. Airway clearance (measured by sputum weight or volume).
6. Number of adverse events (any undesired outcome due to the intervention).

Search methods for identification of studies

Electronic searches

For the 2018 update we searched the Cochrane Central Register of Controlled Trials (CENTRAL; 2018, Issue 1), part of the Cochrane Library (www.thecochranelibrary.com) (accessed 22 February 2018), which includes the Cochrane Acute Respiratory Infections Group Specialised Register, MEDLINE (Ovid) (1946 to 22 February 2018), Embase (Elsevier) (1974 to 22 February 2018), CINAHL (Cumulative Index to Nursing and Allied Health Literature) (EBSCO) (1981 to 22 February 2018), LILACS (Latin American and Caribbean Health Science Information database) (BIREME) (1982 to 22 February 2018), Web of Science (Thomson Reuters) (1950 to 22 February 2018), and PEDro (Physiotherapy Evidence Database) (www.pedro.org.au) (1950 to 22 February 2018).

For this 2018 update we adapted the MEDLINE search strategy (Appendix 2) to search Embase (Appendix 3), CINAHL (Appendix 4), LILACS (Appendix 5), Web of Science (Appendix 6), and PEDro (Appendix 7) from May 2013 to 22 February 2018. We imposed no language or publication restrictions.

Previous searches are presented in Appendix 8.

Searching other resources

We searched the US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov (www.clinicaltrials.gov) and the World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) (apps.who.int/trialsearch/) (22 February 2018). We assessed the reference lists of relevant articles for additional studies.

Data collection and analysis

Selection of studies

Two review authors (PN, TS) independently screened titles and abstracts all the studies identified by the search for potential relevance. We retrieved the full-text study reports of potentially relevant studies, and two review authors (PN, TS) independently screened the full-texts and identified studies for inclusion, and identified and recorded reasons for exclusion of ineligible studies. Any disagreements were resolved through discussion or by consulting a third review author (KM) when necessary. We identified and excluded duplicates and collated multiple reports of the same study so that each study, rather than each report, was the unit of interest in the review. We recorded the selection process in sufficient detail to complete a PRISMA flow diagram and Characteristics of included studies and Characteristics of excluded studies tables (Moher 2009). We did not impose any language restrictions.

Data extraction and management

We used a data collection form for study characteristics and outcome data that was piloted on one study in the review. One review author (KM) extracted study characteristics from the included studies. We extracted the following study characteristics.

1. Methods: study design, total duration of study, details of any 'run in' period, number of study centres and location, study setting, withdrawals, and date of study.
2. Participants: N, mean age, age range, gender, severity of condition, diagnostic criteria, baseline lung function, smoking history, inclusion criteria, and exclusion criteria.
3. Interventions: intervention, comparison, concomitant medications, and excluded medications.
4. Outcomes: primary and secondary outcomes specified and collected, and time points reported.
5. Notes: funding for trial, and notable conflicts of interest of trial authors.

Two review authors (KM, GF) independently extracted outcome data from the included studies. We noted in the Characteristics of included studies table if outcome data were not reported in a usable way. Any disagreements were resolved by consensus or by involving a third review author (PN). One review author (GC) transferred data into the Review Manager 5 file (Review Manager 2014). We double-checked that data were entered correctly by comparing data presented in the systematic review with the study reports. A second review author (PN) spot-checked study characteristics for accuracy against the trial report.

Assessment of risk of bias in included studies

Two review authors (DF, GC) independently assessed risk of bias for each study using the criteria outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011a). Any disagreements were resolved by discussion or by involving another review author (PN). We assessed risk of bias according to the following domains.

1. Random sequence generation.
2. Allocation concealment.
3. Blinding of participants and personnel.
4. Blinding of outcome assessment.
5. Incomplete outcome data.
6. Selective outcome reporting.
7. Other bias.

We graded each potential source of bias as high, low, or unclear and provided quotes from the study report together with a justification for our judgement in the 'Risk of bias' table. We summarised the 'Risk of bias' judgements across different studies for each of the domains listed. We considered blinding separately for different key outcomes where necessary. Where information on risk of bias related to unpublished data or correspondence with a trialist, we noted this in the 'Risk of bias' table.

When considering treatment effects, we took into account the risk of bias for the studies that contributed to that outcome.

Studies were considered as being at low risk of bias overall if at least four of seven domains were assessed as low risk. Studies were considered as being at high risk of bias if more than four domains were assessed as high risk (Anderson 2016).

Assessment of bias in conducting the systematic review

We conducted the review according to the published protocol and reported any deviations from it in Differences between protocol and review.

Measures of treatment effect

We entered outcome data for each study into data tables in Review Manager 5 to calculate treatment effects (Review Manager 2014). We used risk ratio for dichotomous outcomes and mean differences or standardised mean differences for continuous outcomes.

We conducted meta-analyses only where this was meaningful, that is where the treatments, participants, and the underlying clinical question were similar enough for pooling to make sense.

For those studies that reported median and interquartile ranges, we extracted and converted the results into means and standard deviations using the online calculator (http://www.comp.hkbu.edu.hk/~xwan/median2mean.html) (Wan 2014).

Unit of analysis issues

Studies with multiple treatment groups

In studies with more than one eligible comparator, we split the shared group into two groups with smaller sample sizes, and included two comparisons (Higgins 2011d).

Cluster-RCTs

We planned to include cluster-RCTs. We would adjust results when the unit of analysis was presented as the total number of individual participants rather than the number of clusters, using the mean cluster size and intracluster correlation coefficient (Higgins 2011d). We planned to combine individually randomised trials for meta-analysis using the generic inverse-variance method as described in Section 16.3 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011d).

Dealing with missing data

We contacted trial authors to request additional information and to obtain missing data.

Assessment of heterogeneity

We evaluated heterogeneity of study results by inspecting the forest plots to detect non-overlapping confidence intervals, with application of the Chi^2 test (with a P value of 0.10 to indicate statistical significance) and by applying the I^2 statistic. Values up to 40% indicate that the heterogeneity may not be important; between 30% and 60% indicate moderate heterogeneity; between 50% and 90% substantial heterogeneity; and between 75% and 100% considerable heterogeneity, according to the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011b). We considered an I^2 statistic with a value of 50% as a moderate level of heterogeneity (Higgins 2011b).

Assessment of reporting biases

The number of included studies was insufficient to construct funnel plots to assess reporting bias among studies. If in future updates

we include sufficient studies, we will reassess the possibility of constructing funnel plots, as described in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011a). We also plan that if asymmetry is present, we will explore possible causes including publication bias, poor methodological quality, and true heterogeneity.

Data synthesis

We pooled data from studies that were clinically homogeneous using Review Manager 5 software (Review Manager 2014). We determined heterogeneity to be moderate, substantial, or significant, as indicated by I^2 statistic values greater than 30%, and used the random-effects model to summarise results. We meta-analysed data for two outcomes. As we could not undertake meta-analyses for most outcomes, we provided a narrative synthesis of the available data.

GRADE and 'Summary of findings' table

We created Summary of findings for the main comparison using the following outcomes: mortality, duration of hospital stay, time to clinical resolution (in days, respiratory rate and peripheral oxygen saturation), and adverse events. We used the five GRADE considerations (study limitations, consistency of effect, imprecision, indirectness, and publication bias) to assess the quality of a body of evidence as it relates to the studies that contribute data to the meta-analyses for the prespecified outcomes (Atkins 2004). We used methods and recommendations described in Section 8.5 and Chapter 12 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011a; Higgins 2011c), employing GRADEpro GDT software (GRADEpro GDT 2014). We justified all decisions to downgrade the quality of studies in footnotes, and made comments to aid readers' understanding of the review where necessary.

Subgroup analysis and investigation of heterogeneity

We planned to carry out the following subgroup analyses if sufficient data were available.

1. Age (infant, children and adolescents).
2. Type of pneumonia (community acquired, nosocomial, etc.).
3. Type of diagnosis (gold standard and non-gold standard).
4. Treatment setting (inpatient or outpatient).
5. Techniques (conventional, modern or instrumental).

Sensitivity analysis

We planned to perform sensitivity analyses to explore the influence on the results of the following factors if sufficient data were available.

1. Study quality (RCTs with poor methodology).
2. Study size (stratified by sample size).
3. Allocation concealment (high risk of bias versus low risk of bias).
4. Participant blinding (high risk of bias versus low risk of bias).
5. Assessor blinding (high risk of bias versus low risk of bias).

RESULTS

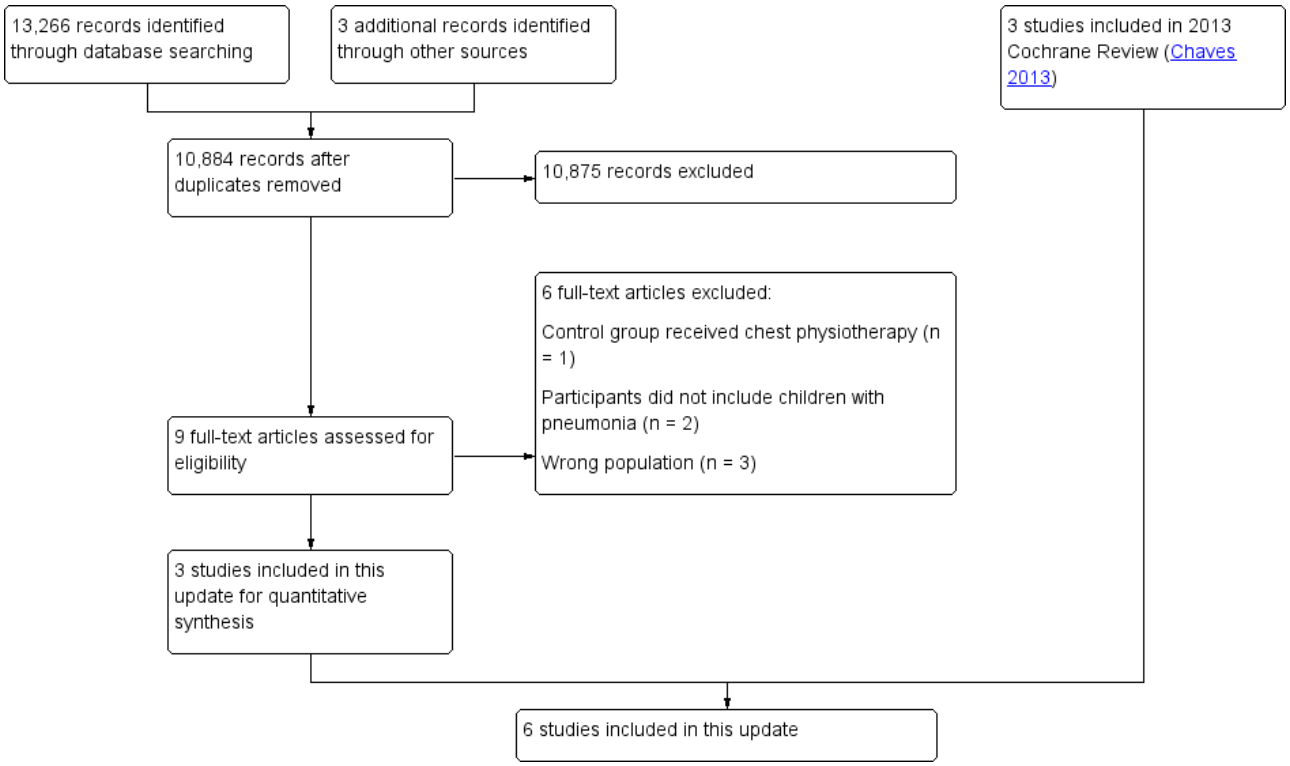
Description of studies

See Characteristics of included studies.

Results of the search

Our previous review included three studies (Chaves 2013). We conducted a search from May 2013 to February 2018 for this update and identified 13,266 records from database searching and three additional records from searching other sources. A total of 10,884 records remained after duplicates were removed, of which we assessed nine full-text reports for eligibility. We included three new trials for this update (Figure 1) (Abdelbasset 2015; Chisti 2015; Corten 2017a).

Figure 1. Study flow diagram.



Included studies

We included six studies that involved a total of 559 children (Abdelbasset 2015; Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008; Zhao 2010). Studies were conducted in Bangladesh (Chisti 2015), Brazil (Lukrafka 2012; Paludo 2008), China (Zhao 2010), Egypt (Abdelbasset 2015), and South Africa (Corten 2017a). Five trials were published in English (Abdelbasset 2015; Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008), and one in Chinese (Zhao 2010).

Study design

All included studies were RCTs. Corten 2017a was described as a pilot RCT.

Participants

The six included studies involved 559 children (aged from 29 days to 12 years), of which 247 children were randomised to treatment groups and 312 to control groups. Lukrafka 2012 stated that only previously healthy children were enrolled, while the other five studies did not report this information. Lukrafka 2012 included only children with community-acquired pneumonia; Corten 2017a included children with community- or hospital-acquired pneumonia; and four trials did not describe pneumonia type (Abdelbasset 2015; Chisti 2015; Paludo 2008; Zhao 2010). Pneumonia severity was described as moderate in one trial (Lukrafka 2012), severe in two trials (Chisti 2015; Zhao 2010), and was not stated in three trials (Abdelbasset 2015; Corten 2017a; Paludo 2008). All studies were conducted in hospital settings.

Interventions

Lukrafka 2012 compared conventional chest physiotherapy with a non-mandatory request to maintain lateral positioning to improve air exchange, coughing to clear secretions, and diaphragmatic and deep breathing for five minutes once daily during the hospital stay. However, the requested lateral positioning was not evaluated.

Two trials compared a conventional chest physiotherapy technique (postural drainage, thoracic squeezing, chest percussion, vibration, cough stimulation, and aspiration of secretions) plus standard treatment for pneumonia with standard treatment for pneumonia alone (Abdelbasset 2015; Paludo 2008).

Zhao 2010 compared continuous positive airway pressure (CPAP) plus standard treatment for pneumonia with standard treatment for pneumonia alone.

Chisti 2015 compared bubble CPAP with low- and high-flow oxygen, according to World Health Organization (WHO) recommendations.

Corten 2017a compared a chest physiotherapy technique (assisted autogenic drainage) with standard nursing care.

The included studies used different types of chest physiotherapy including conventional chest physiotherapy, breathing exercises, and positive expiratory pressure. Only one included study compared the intervention group with two control groups (Chisti 2015). For this review, we compared the intervention group with both control groups separately (i.e. we split the intervention group in half and compared each half with each control group). We considered the mean and standard deviation presented in the original paper and then compared one half with the first control

group (i.e. low-flow oxygen) and the other half with the second control group (i.e. high-flow oxygen).

All children received antibiotic treatment and oxygen support if clinically indicated (Abdelbasset 2015; Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008; Zhao 2010).

Outcomes

Mortality

Two studies reported mortality (Chisti 2015; Corten 2017a). One study (Lukrafka 2012) did not assess mortality as an outcome, but the trial authors reported that no deaths had occurred.

Duration of hospital stay

Four studies assessed duration of hospital stay (Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008).

Time to clinical resolution

Two studies evaluated time to clinical resolution in days (Abdelbasset 2015; Paludo 2008). All included studies evaluated clinical resolution and reported the following clinical parameters:

1. peripheral oxygen saturation levels (Abdelbasset 2015; Chisti 2015; Corten 2017a; Paludo 2008; Zhao 2010);
2. time to normalisation of peripheral oxygen saturation (Chisti 2015; Paludo 2008);
3. fever (Corten 2017a; Paludo 2008); and
4. normalisation of respiratory rate (Abdelbasset 2015; Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008).

Adverse events

Two studies reported adverse events (Chisti 2015; Corten 2017a).

Study funding sources

Studies were supported by government, Chisti 2015; Lukrafka 2012; Paludo 2008, and academic funding sources (Corten 2017a). Two studies did not report funding sources (Abdelbasset 2015; Zhao 2010).

Excluded studies

We excluded 10 trials. The most common reasons for exclusion were lack of a suitable control group, Brunetto 2002; Campos 2007; Santos 2009, and studies that included adults (Brambilla 2014; Ivanov 2015; Kuyrukluyildiz 2016). Two studies did not include children with pneumonia (Jayashree 2016; Leelarungrayub 2016), and in two studies, children in the control group received physiotherapy (Kole 2014; Lanza 2009). See Characteristics of excluded studies.

Risk of bias in included studies

We assessed no studies as at low risk of bias for all domains. Studies were at an overall low risk of bias with regard to blinding of participants and personnel (5/6 studies). We assessed Zhao 2010 as at unclear risk of bias (4/6 domains); Corten 2017a as at low risk of bias (5/6 domains); and Lukrafka 2012 as at high risk of bias for two domains. See Figure 2; Figure 3.

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

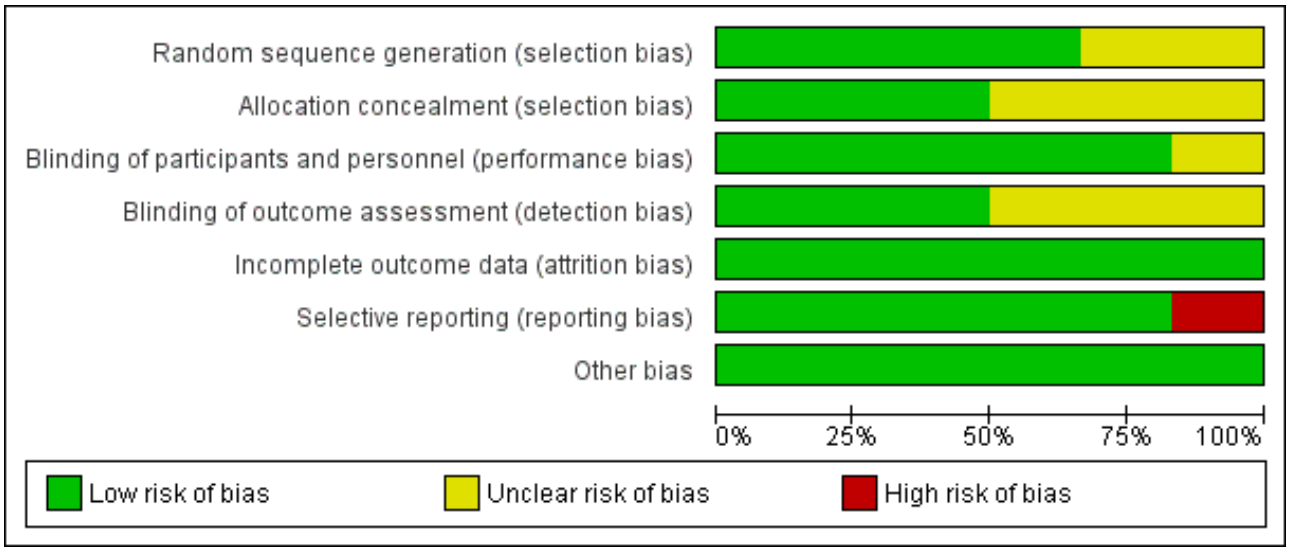
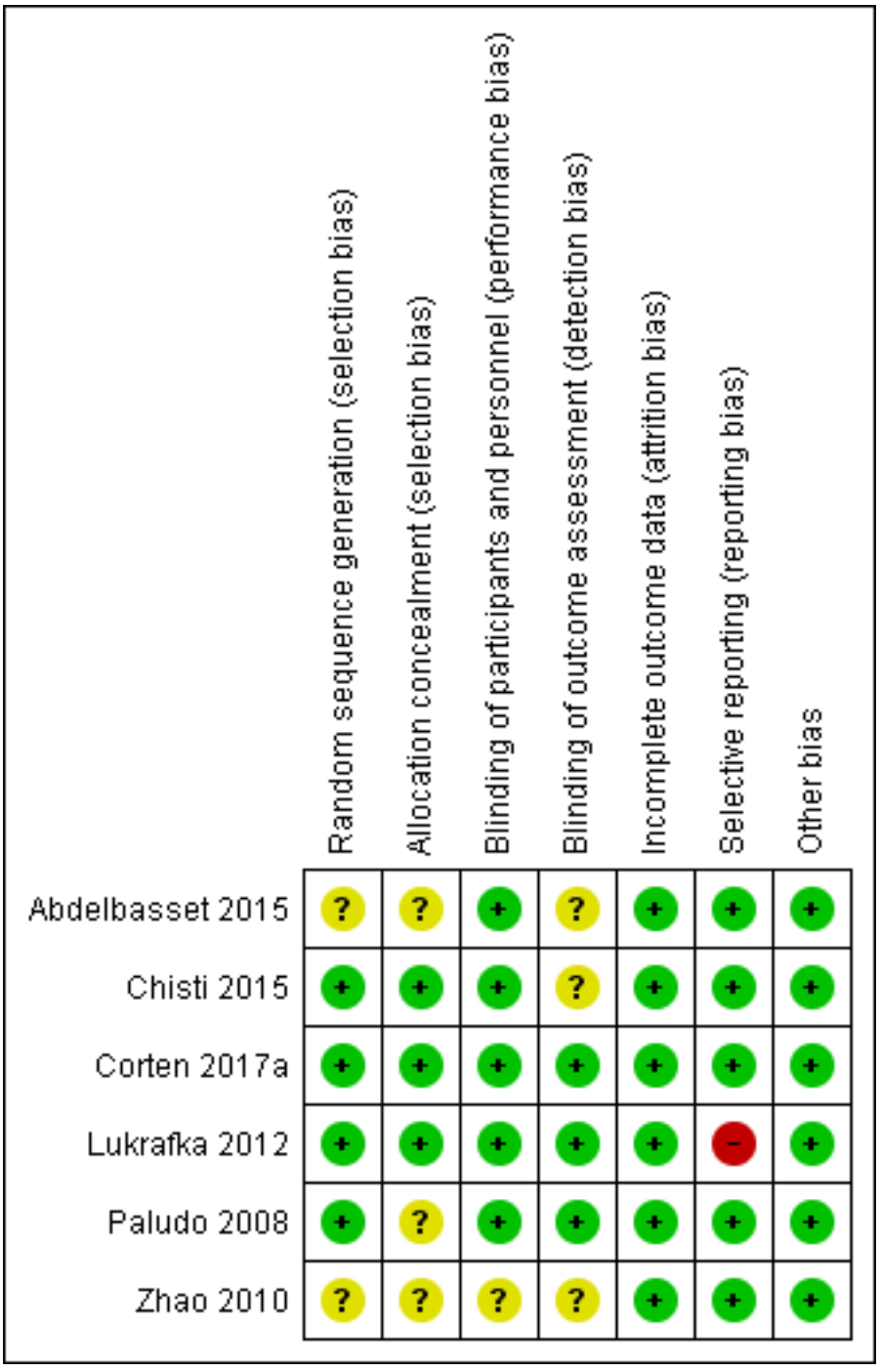


Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



Allocation

Four studies described sequence generation adequately and were judged to be at low risk of bias (Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008). We assessed two trials as at unclear risk of bias for random sequence generation due to insufficient reporting (Abdelbasset 2015; Zhao 2010). Three studies clearly reported methods of allocation concealment and were assessed as at low risk of bias (Chisti 2015; Corten 2017a; Lukrafka 2012). We assessed three studies as at unclear risk of bias for allocation concealment due to insufficient reporting (Abdelbasset 2015; Paludo 2008; Zhao 2010).

Blinding

Five trials stated that blinding of participants and personnel was not possible; we assessed these studies as at low risk of bias once it was confirmed that outcomes were unlikely to be influenced by lack of blinding (Abdelbasset 2015; Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008). Abdelbasset 2015 described blinding of participants and personnel and was assessed as at low risk of

bias. We judged Zhao 2010 as at unclear risk of bias for this domain due to insufficient reporting.

Three studies described blinding of outcome assessors and were classified as at low risk of bias (Corten 2017a; Lukrafka 2012; Paludo 2008). We assessed three trials as at unclear risk of bias due to insufficient reporting (Abdelbasset 2015; Chisti 2015; Zhao 2010).

Incomplete outcome data

Three trials described withdrawals and dropouts and were judged as at low risk of bias because missing outcome data were balanced numerically across the intervention groups (Corten 2017a; Lukrafka 2012; Paludo 2008). The remaining three trials had no withdrawals or dropouts and were assessed as at low risk of bias (Abdelbasset 2015; Chisti 2015; Zhao 2010).

In Lukrafka 2012, of 79 randomised children, four underwent chest drainage (three in the intervention group), and three children in the control group had atelectasis detected on chest x-ray, therefore 72 children (35/37 intervention/control) remained in the study and follow-up (Lukrafka 2012). In Paludo 2008, of 98 randomised children, four withdrew from the intervention group: two were discharged or transferred before the second assessment, and two met an exclusion criterion; and five children withdrew from the control group: two were discharged before the second assessment and three met an exclusion criterion, therefore 89 children (47/42 intervention/control) remained in the study and follow-up (Paludo 2008). In Corten 2017a, of 34 randomised children, one child was hospitalised for less than two days; the medical record of one child was misplaced at the time of recruitment, which led to a recent history of pneumothorax being identified after enrolment; and one child was diagnosed with bronchiolitis and two with asthma.

All participants in Zhao 2010 (N = 94, intervention/control = 47/47), Abdelbasset 2015 (N = 50, intervention/control = 25/25), and Chisti 2015 (N = 255, intervention/control = 79/146) completed treatment.

Selective reporting

Chisti 2015 was registered on ClinicalTrials.gov and Corten 2017a on Pan African Clinical Trials Registry; both studies were assessed as at low risk of bias. Lukrafka 2012 was registered on ClinicalTrials.gov, but as there was no information regarding outcomes this study was assessed as at high risk of bias. We did not find the remaining three studies on trials registers (Abdelbasset 2015; Paludo 2008; Zhao 2010), however as these studies adequately reported all outcome data, we assessed them as at low risk of bias (Abdelbasset 2015; Paludo 2008; Zhao 2010).

Other potential sources of bias

All included studies appeared to be free of other sources of bias and were assessed as at low risk of bias (Abdelbasset 2015; Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008; Zhao 2010).

Effects of interventions

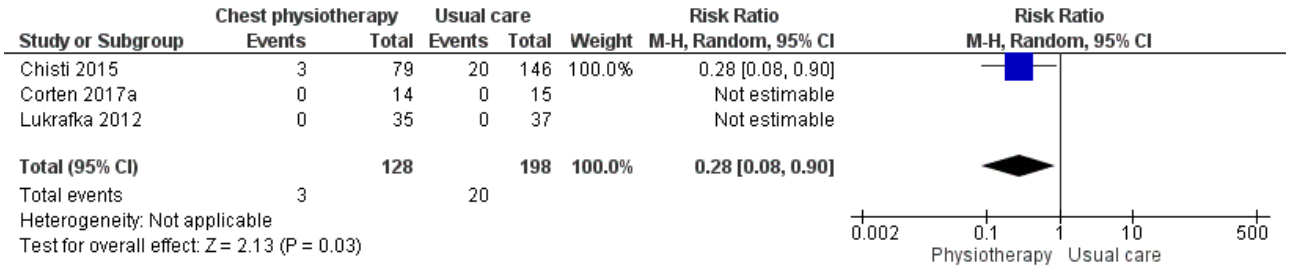
See: **Summary of findings for the main comparison** Chest physiotherapy compared to no chest physiotherapy for pneumonia in children

Primary outcomes

1. Mortality

Two studies (254 children) assessed mortality as an outcome (Chisti 2015; Corten 2017a). Corten 2017a considered mortality as an adverse event and reported that no adverse events had occurred. Chisti 2015 reported that 23 deaths occurred among 225 children: 20 in the control group (no chest physiotherapy) and three in the intervention group (bubble continuous positive airway pressure (bCPAP)). A comparison of bCPAP versus low-flow oxygen therapy favoured bCPAP (risk ratio (RR) 0.25, 95% confidence interval (CI) 0.07 to 0.89; P = 0.02). However, there was no significant difference between bCPAP and high-flow oxygen therapy (RR 0.30, 95% CI 0.09 to 1.05; P = 0.08). A comparison of bCPAP versus both types of oxygen therapy showed that bCPAP therapy reduced risk of death (RR 0.28, 95% CI 0.08 to 0.90; low-quality evidence; Figure 4; Analysis 1.1).

Figure 4. Forest plot of comparison: 1 Chest physiotherapy compared with no chest physiotherapy, outcome: 1.1 Mortality.

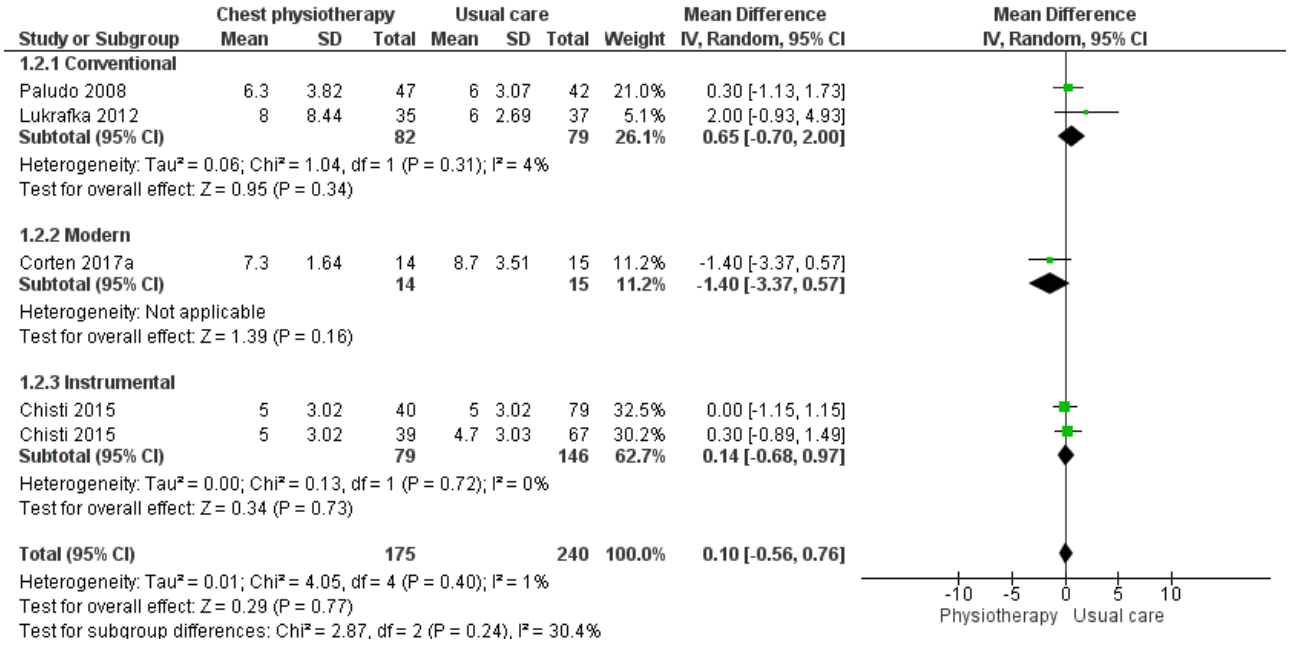


Lukrafka 2012 did not assess mortality as an outcome, but the trial authors reported that no deaths had occurred. Three studies did not report if deaths occurred (Abdelbasset 2015; Paludo 2008; Zhao 2010).

2. Duration of hospital stay (days)

Four studies (415 children) reported length of hospital stay (Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008). We performed a subgroup analysis for this outcome by techniques (conventional, modern and instrumental) as shown in Figure 5. No difference was found between subgroups (test for subgroup differences: Chi^2 = 2.87, df = 2 (P = 0.24), I^2 = 30.4%) and all studies reported that there was no difference between the chest physiotherapy and usual care groups (mean difference (MD) 0.10, 95% CI -0.56 to 0.76; I^2 = 1%); low-quality evidence; Figure 5; Analysis 1.2).

Figure 5. Forest plot of comparison: 1 Chest physiotherapy compared with no chest physiotherapy, outcome: 1.2 Duration of hospital stay.



3. Time to clinical resolution (days) of fever, increase of respiratory work (chest indrawing, nasal flaring, tachypnoea), and peripheral oxygen saturation levels

All included studies assessed time to clinical resolution. However, Abdelbasset 2015 and Lukrafka 2012 did not provide detailed reporting for some parameters considered for time to clinical resolution: Abdelbasset 2015 did not report detailed information about fever, chest indrawing, and nasal flaring separately, and Lukrafka 2012 did not report detailed information about tachypnoea, fever, and oxygen saturation.

Abdelbasset 2015 reported a significant difference between the intervention (conventional chest physiotherapy plus standard treatment for pneumonia) and the control group (standard treatment for pneumonia) for time to clinical resolution in days (P = 0.01). Abdelbasset 2015 defined time to clinical resolution as the number of days needed for a participant to achieve the following clinical parameters: no fever (daily maximum body temperature < 37.5 °C), absence of severe signs (chest indrawing, nasal flaring), normal respiratory rate, and arterial oxygen saturation > 95%.

Lukrafka 2012 reported time to clinical resolution as a severity score, respiratory rate, fever, and oxygen saturation. There were differences between baseline and discharge in both the intervention and the control group in severity score and respiratory rate (P < 0.001), favouring the intervention group (conventional chest physiotherapy).

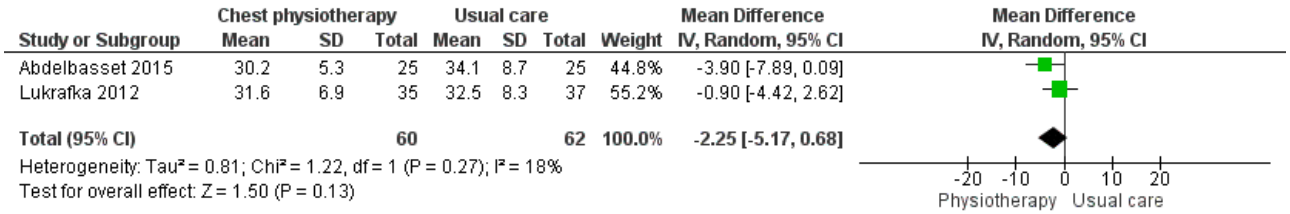
Fever

Paludo 2008 reported no significant differences between conventional chest physiotherapy plus standard treatment for pneumonia and standard treatment for children with pneumonia in terms of fever as a parameter of clinical resolution (P = 0.78). Corten 2017a found no significant differences between autogenic assisted drainage and standard nursing care (mean standard deviation 1.00, range -0.6 to 2.6).

Increased respiratory effort (chest indrawing, nasal flaring, tachypnoea)

Five studies evaluated respiratory rate as a clinical parameter of time to clinical resolution (Abdelbasset 2015; Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008). Chisti 2015 and Paludo 2008 evaluated time to normalisation of respiratory rate: Paludo 2008 found no difference between conventional chest physiotherapy and no chest physiotherapy (P = 0.75), while Chisti 2015 reported a difference between bCPAP versus low-flow oxygen therapy (P = 0.04), but no difference between bCPAP and high-flow oxygen therapy (P = 0.35). Corten 2017a found no significant difference between assisted autogenic drainage and standard nursing care. Data from Abdelbasset 2015 and Lukrafka 2012 (122 children) did not demonstrate a significant difference between conventional chest physiotherapy and control (MD -2.25, 95% CI -5.17 to 0.68; low-quality evidence; Figure 6; Analysis 1.3). Corten 2017a was excluded from the meta-analysis because data were reported as median and interquartile range only.

Figure 6. Forest plot of comparison: 1 Chest physiotherapy compared with no chest physiotherapy, outcome: 1.3 Time to clinical resolution (respiratory rate).



Peripheral oxygen

Five studies considered peripheral oxygen saturation levels (Abdelbasset 2015; Chisti 2015; Corten 2017a; Paludo 2008; Zhao 2010). Children who received CPAP had improved peripheral oxygen saturation levels (P < 0.001) (Zhao 2010). Abdelbasset 2015 reported that children who received conventional chest physiotherapy showed a greater improvement in peripheral oxygen saturation levels (P = 0.002) than children receiving standard treatment for pneumonia. Corten 2017a found no significant difference between assisted autogenic drainage and standard nursing care (mean standard deviation 0.1, 95% CI -2.6 to 2.8). Paludo 2008 reported no significant difference between conventional chest physiotherapy and no chest physiotherapy for time to normalisation of peripheral oxygen saturation (P = 0.98). Chisti 2015 found no significant difference between bCPAP and low-flow oxygen therapy (P = 0.77) and between bCPAP and high-flow oxygen therapy (P = 0.47).

Secondary outcomes

1. Change in adventitious sounds

Paludo 2008 assessed change in adventitious sounds and reported that children who received conventional chest physiotherapy plus standard treatment for pneumonia had a longer median duration of rhonchi on lung auscultation (P = 0.03) than children who received standard care.

2. Change in chest x-ray

Lukrafka 2012 assessed the presence of pleural effusion on chest x-ray as a measure of severity which was measured as a score that also included other variables such as tachypnoea, recession (suprasternal, intercostal, and subcostal), desaturation, and fever. There were no differences between children who received conventional chest physiotherapy and those who did not receive chest physiotherapy.

3. Duration (days) of antibiotic therapy, cough and sputum production

Paludo 2008 assessed days of cough and sputum production and reported that children who received conventional chest physiotherapy had longer median duration of coughing (P = 0.04) than children who received standard treatment for pneumonia only.

4. Duration (days) of leukocytosis

None of the included studies reported this outcome.

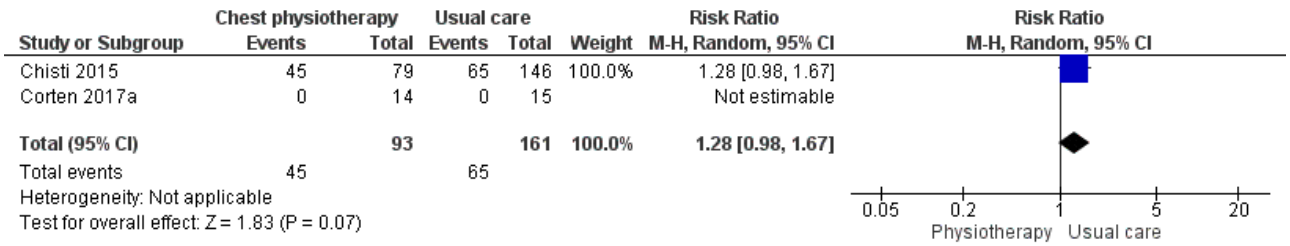
5. Airway clearance (measured by sputum weight or volume)

None of the included studies reported this outcome.

6. Number of adverse events (any undesired outcome due to the intervention)

Two studies (254 children) reported on adverse events (Chisti 2015; Corten 2017a). Corten 2017a reported no adverse events in either the intervention (assisted autogenic drainage) or control group children (standard nursing care). Chisti 2015 reported that 34 children (15%) developed clinical signs of heart failure; 9 (4%) developed generalised convulsions; 17 (8%) developed hyponatraemia; and 28 (12%) developed hypernatraemia. The number of adverse events in Chisti 2015 was higher in the usual care group compared to the bCPAP group (RR 1.28, 95% CI 0.98 to 1.67; low-quality evidence; Figure 7; Analysis 1.4), however we could not attribute this finding to the type of intervention provided.

Figure 7. Forest plot of comparison: 1 Chest physiotherapy compared with no chest physiotherapy, outcome: 1.4 Adverse events.



We were unable to pool data for meta-analysis due to heterogeneity among studies.

DISCUSSION

Summary of main results

We assessed the effectiveness of chest physiotherapy with regard to mortality rate, duration of hospital stay, and time to clinical resolution in children with pneumonia. We included six randomised controlled trials (RCTs) (559 children) that appraised different types of chest physiotherapy (standardised chest physiotherapy, positive expiratory pressure, continuous positive airway pressure (CPAP), bubble CPAP (bCPAP), and assisted autogenic drainage).

Two included studies reported mortality, but only one reported finding a lower number of deaths in the intervention group (bCPAP). Duration of hospital stay in children with pneumonia was not reduced by chest physiotherapy. However, there was a decrease in time to clinical resolution (days) in children who received standardised chest physiotherapy. Two studies reported improvements in blood oxygen levels after chest physiotherapy (CPAP and conventional chest physiotherapy). However, no clear improvement in respiratory rate was observed after conventional chest physiotherapy.

Four studies reported sources of funding (Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008), while two studies did not provide this information (Abdelbasset 2015; Zhao 2010).

Overall completeness and applicability of evidence

We assessed the effectiveness of chest physiotherapy with regard to time to clinical resolution in children (from birth to 18 years) of either gender, with any type of pneumonia. However, the included studies only assessed inpatient children aged from 29 days to 12 years. The participants' age could be considered a limitation in the applicability of the evidence in current practice due to the fact that the techniques applied to the target population were restricted to assisted techniques. The included studies did not address all of our prespecified outcomes. However, most of our prespecified outcomes were reported by at least one study. Only two studies assessed mortality (Chisti 2015; Corten 2017a); four studies assessed duration of hospital stay (Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008); and all included studies evaluated time to clinical resolution (Abdelbasset 2015; Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008; Zhao 2010). However, different parameters (e.g. number of days, respiratory rate and oxygen saturation) were considered.

Lukrafka 2012 evaluated some parameters such as fever, tachypnoea, and peripheral oxygen saturation levels, but these were reported as a severity score. In Paludo 2008, the trial authors expressed the baseline values as mean deviations and standard deviations, and postintervention values as median and interquartile range. In Zhao 2010 and Abdelbasset 2015, the baseline and postintervention values were reported as mean deviations and standard deviations. In Chisti 2015 and Corten 2017a, all values were reported as median and interquartile range. As a consequence, we were able to perform meta-analyses for few outcomes (mortality, duration of hospitalisation, time to clinical resolution, and adverse events).

The chest physiotherapy techniques used in the included studies did not cover all existing techniques for children with pneumonia. Variation occurs in the application of specific chest physiotherapy techniques, both in the literature and in practice. Different airway clearance techniques can be considered heterogeneous due to their different mechanisms of action and different physiological principles (Button 2013), some of which involve the assistance of another person such as a physiotherapist, and others that must be self administered or require mechanical devices (Main 2005; Morrison 2017). However, these techniques may be used alone or in combination (Boeck 2008; Snijders 2015). Moreover, the different levels of severity, types of pneumonia, and medications used may have affected the practice of physiotherapy as well as the duration of hospital stay. While the application of chest physiotherapy led to improvement in some clinical aspects, it also led to a worsening of other factors, such as cough and rhonchi on lung auscultation (Paludo 2008). An explanation for this is that some of the chest physiotherapy techniques applied in children (in these trials) are also used in adults, and may not be appropriate for children considering their anatomical and physiological differences (Oberwaldner 2000).

Furthermore, some limitations related to methodological aspects in the included studies may have compromised the quality of the evidence of this review. Randomisation, allocation concealment, and blinding were the main sources of bias. In addition, while most trials reported the results of their outcomes, these were reported in such a way that prevented pooling of the results in a meta-analysis.

Quality of the evidence

We assessed the evidence as low quality according to GRADE criteria. Our review was limited by the lack of studies and the quality of the existing evidence. We downgraded the quality of the evidence because outcome measures were ascertained using different criteria and involved small numbers of children, and related to the 'Risk of bias' assessment.

Four studies explained how randomisation was conducted and were classified as at low risk of bias (Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008). Three studies described allocation concealment and were judged as at low risk of bias (Chisti 2015; Corten 2017a; Lukrafka 2012). According to Moher 2001, inadequately reported randomisation has been associated with bias in estimating the effectiveness of interventions. Savović 2012 showed that inadequate reporting of trial methods can severely impede the assessment of trial quality and the risk of bias in trial results. This is particularly a problem for assessment of sequence generation and allocation concealment, which are often not described in trial publications. Three studies reported adequate blinding of outcome assessment and were judged as at low risk of bias (Corten 2017a; Lukrafka 2012; Paludo 2008). Five trials described chest physiotherapy as being performed by a physiotherapist, therefore blinding of practitioners may be difficult (Abdelbasset 2015; Chisti 2015; Corten 2017a; Lukrafka 2012; Paludo 2008). In an RCT, at least three distinct groups (trial participants, trial personnel, and outcome assessors) can potentially be blinded (Savović 2012). The description of these methodological items is recommended by the CONSORT 2010 statement (CONSORT 2010). Moreover, there are challenges in obtaining high-quality evidence for physiotherapy interventions due to the difficulties in blinding the intervention, standardising the method of chest physiotherapy, and defining clinically meaningful outcomes (Yang 2013). We found three protocols for included studies in trials registers, but there was no information regarding

outcomes (Chisti 2015; Corten 2017a; Lukrafka 2012). This aspect is covered in the CONSORT 2010 checklist of information to include when reporting a randomised trial (CONSORT 2010). A study's protocol registration provides information such as the main objective of the study, inclusion and exclusion criteria, primary and secondary outcomes, and other methodological aspects. Clinical trial registration minimises or avoids the consequences of non-publication of entire trials and selective reporting of outcomes within trials (CONSORT 2010; CONSORT 2017).

Potential biases in the review process

We undertook a systematic search of the literature to identify all studies that met our inclusion criteria. Two review authors independently cross-checked study selection, data extraction, and 'Risk of bias' decisions.

In addition to the paucity of data provided by the six included studies, most of them reported the available data differently. Consequently, most outcomes could not be pooled in a meta-analysis, and this may be considered a potential source of bias in our review. Another factor to consider was the inability to conduct a subgroup analysis by age.

Where possible we contacted trial authors to obtain additional information about unpublished data in an effort to resolve these problems. However, we were not able to obtain further data from all included trials. The time of application of the techniques, the different techniques applied and follow-up can also be considered a potential source of bias. All of these factors varied between studies or were not reported.

Agreements and disagreements with other studies or reviews

Chest physiotherapy has been widely used to treat people with pneumonia, but the evidence is weak (Bowen 2013; Harris 2011; Leelarungrayub 2016). Although three new studies were included in this update, few RCTs have been performed on this topic; chest physiotherapy is associated with high costs because trained professionals and equipment are required (Damiani 2015; Guessous 2008).

There is one previously published systematic review about chest physiotherapy, but it focused on adults with pneumonia (Yang 2013). However, the results of that review did not show evidence of the effectiveness of physiotherapy for people with pneumonia, which support our findings. In the Yang 2013 review, all included studies were reported to be of poor to moderate methodological quality. To our knowledge, ours is the first systematic review to assess the effectiveness of chest physiotherapy in children with pneumonia.

AUTHORS' CONCLUSIONS

Implications for practice

We could draw no reliable conclusions concerning the use of chest physiotherapy for children with pneumonia. One small study of one technique, bubble continuous positive airway pressure, showed potentially favourable results in terms of mortality and respiratory rate. The results were limited by the lack of studies, variation in the characteristics of the included studies, high risk of performance bias, and statistical presentation of data.

Implications for research

Although we included three additional studies for this update, well-conducted randomised controlled trials addressing the use of chest physiotherapy in children with pneumonia are needed. Future studies should report methodological aspects such as adequate random sequence generation, allocation concealment, and blinding of outcome assessors. Moreover, studies should consider the following key points: appropriate sample size with power to detect expected differences, standardisation of chest physiotherapy techniques, appropriate outcomes (such as duration of leukocytosis, and airway clearance), adverse effects, and reporting the results in such a way that permits meta-analysis. Furthermore, the reporting of randomised trials should follow the CONSORT statement (CONSORT 2010).

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CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Abdelbasset 2015

Methods	**Design:** RCT **Method of randomisation:** not described **Method of allocation concealment:** not described **Outcome assessor blinding:** not described **Withdrawal/dropouts:** not described
Participants	**Country:** Egypt **Setting:** hospital **Health status:** acute pneumonia, severity not described **Total sample:** 50 children (25 in each group) **Mean age:** 36.0 ± 21.3 months (intervention group) and 35.0 ± 28.1 (control group) **Age range:** children aged 29 days to 2 years **Exclusion criteria:** patients who suffered chest drain, haemodynamic instability, bone fragility or rib fractures, and any other contraindication to chest physical therapy
Interventions	Duration: active treatment: chest physiotherapy 3 times daily with standard treatment for pneumonia Intervention group: each session was about 20 min and included postural drainage, thoracic squeezing, chest percussion, vibration, cough stimulation and aspiration of secretions (if needed). The position for postural drainage was directed by the chest radiograph to provide more effective drainage of secretions and exudates from the most affected areas. Control group received standard treatment for pneumonia with antibiotic therapy, fluid therapy, and oxygen therapy (if needed).

Abdelbasset 2015 *(Continued)*

	Children were clinically evaluated at enrolment of the study and at discharge.
Outcomes	• Time to clinical resolution: afebrile, absence of severe signs (chest indrawing, nasal flaring, and cyanosis), normal respiratory rate, and arterial oxygen saturation > 95% • Changes of respiratory rate and arterial oxygen saturation
Notes	Funding support: not described

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Insufficient information to permit assessment
Allocation concealment (selection bias)	Unclear risk	Insufficient information to permit assessment
Blinding of participants and personnel (performance bias) All outcomes	Low risk	The paediatrician was blinded to group assignment and study protocol. All physicians and nurses were blinded to group assignment and study protocol. Different schedules were arranged for the physicians and physiotherapist to avoid their chance encounter at a participant's bedside. No blinding of participants, but the review authors judge that the outcomes are not likely to be influenced by lack of blinding.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing outcome data
Selective reporting (reporting bias)	Low risk	The study protocol was not available, but it is clear that the published reports included all expected outcomes, including those that were prespecified.
Other bias	Low risk	The study appears to be free of other sources of bias.

Chisti 2015

Methods	**Design:** RCT **Method of randomisation:** participants were randomly assigned (1:1:1) to 1 of 3 groups: bubble CPAP, standard low-flow oxygen therapy, or high-flow oxygen therapy. Randomisation was done employing permuted block methods, using Fisher and Yates tables of random permutations. **Method of allocation concealment:** the randomisation numbers were provided to the study investigators in sequentially numbered, sealed, opaque envelopes containing the name of the treatment on a card inside the envelope. **Outcome assessor blinding:** not described **Withdrawal/dropouts:** not described
Participants	**Country:** Bangladesh

Chisti 2015 *(Continued)*

	Setting: hospital **Health status:** severe pneumonia **Total sample:** 225 children (79 in bubble CPAP therapy group; 67 in low-flow oxygen therapy group; 79 in high-flow oxygen therapy group) **Age range:** children aged 3.8 months to 13 years **Exclusion criteria:** children with known congenital heart disease, asthma, or upper airway obstruction, and premature infants (unless their corrected age was 0 month or older). Children who already fulfilled the definition of treatment failure at presentation were also not recruited.
Interventions	All children received WHO standard management for very severe pneumonia, including parental ampicillin and gentamicin, nasogastric feeding or intravenous fluids if the child had very severe respiratory distress, and hourly monitoring of clinical signs of respiratory distress and SpO_2. Duration: active treatment: not described Intervention group: the bubble CPAP system was constructed locally using standard nasal oxygen prongs. Gas flow was provided by oxygen concentrators in most cases. The positive end-expiratory pressure provided by CPAP was started at 5 cm H_2O and increased up to 10 cm H_2O if the child was not responding. Control group: • Low-flow oxygen therapy was delivered directly from oxygen cylinders via nasal cannula. Flow rates of oxygen were 0.5 to 2 L/min for children younger than 2 years and 2 to 4 L/min for children 2 years of age and older, according to WHO recommendations. • High-flow oxygen therapy was used by an oxygen concentrator to provide a mixture of air and oxygen of 2 L/kg of bodyweight/min up to a maximum of 12 L/min. The high-flow oxygen was passed through a room temperature water humidifier to prevent drying of nasal mucosa and delivered via nasal oxygen prongs, as previously described. Re-evaluated at discharge
Outcomes	• Treatment failure defined as 2 or more of the following criteria: severe hypoxaemia (SpO_2 < 85%) after at least 30 min of study intervention; signs of severe respiratory distress, including moderate to severe chest wall indrawing, tracheal tug, nasal flaring, or grunting respirations; and partial pressure of carbon dioxide greater than 60 mm Hg and pH > 7.2 in capillary blood gas • Length of hospital stay • Nosocomial infections • Rate of isolation of *Mycobacterium tuberculosis* • Bacterial aetiology • Multi-organ failure at 7 days
Notes	In view of the high mortality associated with mechanical ventilation at Dhaka Hospital (protocol), the authors planned for children who had treatment failure on low-flow oxygen therapy to be given bubble CPAP or high-flow oxygen therapy as a second-line therapy after re-randomisation. If a child fulfilled the criteria for clinical failure on bubble CPAP or high-flow oxygen therapies, he or she was put on mechanical ventilation. The funders had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. Funding support: the research was funded by the Centre for International Child Health, through a Knowledge Hubs for Health grant from the Australian Agency for International Development (AusAID; grant number Gr 00837). Author (MJC) received a PhD scholarship from the University of Melbourne to complete this study.
Risk of bias	

Chisti 2015 *(Continued)*

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were randomly assigned (1:1:1) to 1 of 3 groups. The randomisation sequence was prepared before study commencement by an independent statistician at the International Centre for Diarrhoeal Disease Research, Bangladesh, who had no other involvement in the trial. Randomisation method: permuted block methods, using Fisher and Yates tables of random permutations
Allocation concealment (selection bias)	Low risk	The randomisation numbers were provided to the study investigators in sequentially numbered, sealed, opaque envelopes containing the name of the treatment on a card inside the envelope.
Blinding of participants and personnel (performance bias) All outcomes	Low risk	No blinding, however the review authors judge that outcomes were not likely to be influenced by lack of blinding.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing outcome data
Selective reporting (reporting bias)	Low risk	The study protocol was available, and all of the study's prespecified (primary and secondary) outcomes that are of interest in the review have been reported.
Other bias	Low risk	The study appears to be free of other sources of bias.

Corten 2017a

Methods	**Design**: this study was a pilot RCT. **Method of randomisation:** participants were randomly allocated to either the intervention or control group (ratio 1:1) using a computer-generated list of random numbers. **Method of allocation concealment:** allocation concealment was maintained by the use of sealed, opaque envelopes. **Outcome assessor blinding:** this study was single-blinded, with blinding of the outcome assessor and data analyst. A blinded outcome assessor performed recruitment and discharge from hospital using a pre-set form. Participants in the intervention group were also assessed pre-treatment, post-treatment, and 1-hour post-treatment by the attending physiotherapist (not blinded to group allocation), using a pre-set form. **Withdrawal/dropouts:** 5 children were excluded after enrolment. Reasons for exclusion postrandomisation were: hospitalised for less than 2 days (N = 1); misplaced medical record at the time of recruitment, resulting in a recent history of pneumothorax being identified after enrolment (N = 1); and diagnoses of bronchiolitis (N = 1) and asthma (N = 2) made postenrolment.
Participants	**Country**: South Africa **Setting**: hospital

Corten 2017a *(Continued)*

	Health status: children hospitalised with a clinical diagnosis and/or radiological confirmation of either community- or hospital-acquired pneumonia **Total sample:** 29 children (N = 14 in the intervention group and N = 15 in the control group) **Median age in months:** 3.5 IQR 1.5 to 9.4 **Age range:** 1 month to 8 years **Exclusion criteria:** bronchiolitis; *Pneumocystis jirovecii* pneumonia; active tuberculosis; any cardiac or respiratory comorbidity; recent history (< 6 months) of pneumothorax or thoracic/abdominal surgery; increased intracranial pressure; pleural effusion with or without intercostal drain; chest deformities; any condition for which mobilisation out of bed was contraindicated; osteoporosis; premature (≤ 30 weeks) birth; hospitalised for less than 2 days; and marked respiratory distress and/or hypoxia (oxygen saturation ≤ 90% on oxygen support and 3 or more of the following clinical signs: cyanosis, weak cry, feeding problems, muscle retraction, head nodding, nasal flaring). Children hospitalised and off mechanical ventilator for more than 4 days prior to recruitment were ineligible for the study (for baseline data purposes).
Interventions	Both groups received standard nursing care, which included oxygen support, suctioning as needed, and regular change of body position. Duration: active treatment: 5 consecutive days, from the day of recruitment Intervention group: the intervention group received additional bi-daily assisted autogenic drainage for 10 to 30 minutes. The length of therapy was determined by the attending physiotherapist, based on signs of respiratory distress, removal of secretions, and fatigue, and was therefore not standardised. The control group did not receive airway clearance therapy, except when prescribed by the physician. This treatment was then classified as "emergency physiotherapy" and could include any airway clearance technique except assisted autogenic drainage.
Outcomes	• Duration of hospitalisation • Days of fever • Duration of oxygen support • Respiratory rate and heart rate adjusted for age at admission, recruitment, and discharge (change over time) • Oxygen saturation in room air at admission, recruitment, and discharge • Adverse events (including hypoxia, acute atelectasis and lung/lobar collapse, based on radiology, if available, and mortality rate)
Notes	Funding support: author (LC) received a scholarship from the University of Cape Town. The Department of Paediatrics and Child Health research award (University of Cape Town) provided funds for operational costs.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were randomly allocated to either the intervention or the control group (ratio 1:1) using a computer-generated list of random numbers.
Allocation concealment (selection bias)	Low risk	Allocation concealment was maintained by the use of sealed, opaque envelopes.
Blinding of participants and personnel (performance bias) All outcomes	Low risk	No blinding, however the review authors judge that the outcomes were not likely to be influenced by lack of blinding.

Corten 2017a *(Continued)*

Blinding of outcome assessment (detection bias) All outcomes	Low risk	This study was single-blinded, with blinding of the outcome assessor and data analyst.
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing outcome data
Selective reporting (reporting bias)	Low risk	The study protocol was available, and all of the study's prespecified (primary and secondary) outcomes that are of interest in the review have been reported.
Other bias	Low risk	The study appears to be free of other sources of bias.

Lukrafka 2012

Methods	**Design:** RCT **Method of randomisation**: children were assigned to 1 of 2 groups. An epidemiologist performed the randomisation using a computerised random number generator to select blocks of 3 and 4. A separate randomisation procedure was performed in each of 2 age group subsets (12 to 59 months and 5 to 12 years). **Method of allocation concealment**: randomisation was concealed by the senior investigator using sequentially numbered, opaque envelopes. **Outcome assessor blinding:** the study radiologist, statistician, and epidemiologist involved in evaluating the outcomes of this RCT did not take part in the clinical attendance and therapeutic decisions. **Withdrawal/dropouts:** after randomisation, 4 participants underwent chest drainage (3 in the intervention group), and 3 participants had atelectasis detected by chest x-ray (all in the control group), with 72 participants (35/37 intervention/control) remaining in the study and follow-up.
Participants	**Country**: Brazil **Setting**: hospital **Health status:** children hospitalised with a clinically and radiologically confirmed diagnosis of acute community-acquired pneumonia **Total sample:** 72 participants (N = 35 in the intervention group and N = 37 in the control group) **Age range:** 1 to 12 years **Exclusion criteria:** participants who were severely ill, such as those hospitalised in intensive care units, with pleural effusion treated with chest drainage, atelectasis detected by x-ray, history of pneumonia or pleural effusion in the previous 6 months, or other pulmonary underlying diseases, heart disease, cerebral palsy, or immune deficiency
Interventions	Duration: active treatment: 3 times daily Intervention group: standardised respiratory physiotherapy (positioning, thoracic vibration, thoracic compression, positive expiratory pressure, breathing exercises and forced exhalation with the glottis open or "huffing") Control group received a non-mandatory request to breathe deeply, expectorate the sputum, and maintain a lateral body position once a day. Re-evaluated at discharge

Lukrafka 2012 *(Continued)*

Outcomes	• Respiratory rate • Temperature • Tachypnoea • Nasal flaring • Suprasternal, intercostal, and subcostal recession • Oxygen saturation • X-ray • Duration of hospitalisation
Notes	The trial author responded to our enquiries but informed us that it was not possible to provide data as means and standard deviations. Funding support: the study was partially supported by the Brazilian National Council on Scientific and Technology Development (CNPq), as a research grant to SCF. CNPq had no involvement in the study.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomisation was performed by an epidemiologist using a computerised random number generator to select blocks of 3 and 4.
Allocation concealment (selection bias)	Low risk	Randomisation was concealed by the senior investigator using sequentially numbered, opaque envelopes.
Blinding of participants and personnel (performance bias) All outcomes	Low risk	No blinding, however the review authors judge that outcomes were not likely to be influenced by lack of blinding.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Blinding of outcome assessment ensured.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Missing outcome data balanced in numbers across intervention groups, with similar reasons for missing data across groups.
Selective reporting (reporting bias)	High risk	The study protocol was available, but there is no information regarding the outcomes.
Other bias	Low risk	The study appears to be free of other sources of bias.

Paludo 2008

Methods	**Design:** RCT **Method of randomisation:** simple randomisation was performed from a table of random numbers. **Method of allocation concealment:** not described **Outcome assessor blinding:** all attending paediatricians were blinded to group assignment and study protocol. **Withdrawal/dropouts:** 9 participants withdrew from the study.

Paludo 2008 *(Continued)*

Participants	**Country**: Brazil **Setting**: hospital **Health status:** participants hospitalised with a diagnosis of acute pneumonia (did not specify the acquisition form) **Total sample:** 89 participants **Age range:** children aged 29 days to 12 years **Exclusion criteria:** children who needed a chest drain, were haemodynamically unstable, had bone fragility or rib fractures or any other contraindication to chest physical therapy were excluded.
Interventions	Duration: active treatment: twice daily Intervention group: each session of chest physical therapy lasted roughly 30 minutes and consisted of postural drainage, thoracic squeezing, chest percussion, vibration, cough stimulation and aspiration of secretions (if necessary). Control group received standard treatment for pneumonia alone. Re-evaluated at discharge
Outcomes	• Time to clinical resolution: afebrile, absence of severe signs (chest indrawing, nasal flaring), normal respiratory rate, and arterial oxygen saturation > 95% • Length of hospital stay and persistence of respiratory symptoms and signs (fever, cough, wheezing, tachypnoea, chest indrawing, adventitious sounds on lung auscultation, and arterial oxygen saturation)
Notes	The author responded to our enquiries and provided further details. Funding support: authors (CP, CSL, and JAB) received grants from Brazilian government research support agencies: the Coordination for the Improvement of Higher Education Personnel, the National Council for the Scientific and Technologic Development, and the Research Assistance Fund of Rio Grande do Sul.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Simple randomisation was performed from a table of random numbers.
Allocation concealment (selection bias)	Unclear risk	Insufficient information to permit judgement
Blinding of participants and personnel (performance bias) All outcomes	Low risk	No blinding, however the review authors judge that outcomes were not likely to be influenced by lack of blinding.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Blinding of outcome assessment ensured.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Missing outcome data balanced in numbers across intervention groups, with similar reasons for missing data across groups.

Paludo 2008 *(Continued)*

Selective reporting (reporting bias)	Low risk	The study protocol was available, but there is no information regarding the outcomes. It is clear however that the published reports included all expected outcomes, including those that were prespecified.
Other bias	Low risk	The study appears to be free of other sources of bias.

Zhao 2010

Methods	**Design:** RCT **Method of randomisation:** not described **Method of allocation concealment:** not described **Outcome assessor blinding:** not described **Withdrawal/dropouts:** not described
Participants	**Country:** China **Setting:** hospital **Health status:** severe pneumonia **Total sample:** 94 children (47 in each group) **Mean age:** 10.79 ± 4.75 months **Age range:** children aged 2 months to 2 years **Exclusion criteria:** not described
Interventions	Duration: active treatment: until the stabilisation of the participant based on oxygen saturation Intervention group: continuous positive airway pressure Control group received standard treatment for pneumonia with oxygen support. Re-evaluated 4 and 12 hours after treatment
Outcomes	Arterial oxygen saturation; arterial oxygen pressure; arterial carbon dioxide pressure
Notes	This paper was translated from the Chinese. Funding support: not described

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Insufficient information to permit judgement
Allocation concealment (selection bias)	Unclear risk	Insufficient information to permit judgement
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Insufficient information to permit judgement

Zhao 2010 *(Continued)*

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Insufficient information to permit judgement
Incomplete outcome data (attrition bias) All outcomes	Low risk	No missing outcome data
Selective reporting (reporting bias)	Low risk	The study protocol was not available, but the published reports include all expected outcomes, including those that were prespecified.
Other bias	Low risk	The study appears to be free of other sources of bias.

CPAP: continuous positive airway pressure
H_2O: water
IQR: interquartile range
RCT: randomised controlled trial
SpO_2: peripheral capillary oxygen saturation
WHO: World Health Organization

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Brambilla 2014	Wrong population: adults included
Brunetto 2002	No control group
Campos 2007	No control group
Ivanov 2015	Wrong population: adults included
Jayashree 2016	Wrong population: participants did not include children with pneumonia
Kole 2014	The control group received chest physiotherapy.
Kuyrukluyildiz 2016	Wrong population: adults included
Lanza 2009	The control group received chest physiotherapy.
Leelarungrayub 2016	Wrong population: participants did not include children with pneumonia
Santos 2009	No control group

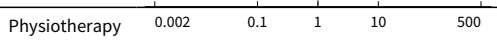
DATA AND ANALYSES

Comparison 1. Chest physiotherapy compared with no chest physiotherapy

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mortality	3	326	Risk Ratio (M-H, Random, 95% CI)	0.28 [0.08, 0.90]
2 Duration of hospital stay	4	415	Mean Difference (IV, Random, 95% CI)	0.10 [-0.56, 0.76]
2.1 Conventional	2	161	Mean Difference (IV, Random, 95% CI)	0.65 [-0.70, 2.00]
2.2 Modern	1	29	Mean Difference (IV, Random, 95% CI)	-1.40 [-3.37, 0.57]
2.3 Instrumental	1	225	Mean Difference (IV, Random, 95% CI)	0.14 [-0.68, 0.97]
3 Time to clinical resolution (respiratory rate)	2	122	Mean Difference (IV, Random, 95% CI)	-2.25 [-5.17, 0.68]
4 Adverse events	2	254	Risk Ratio (M-H, Random, 95% CI)	1.28 [0.98, 1.67]

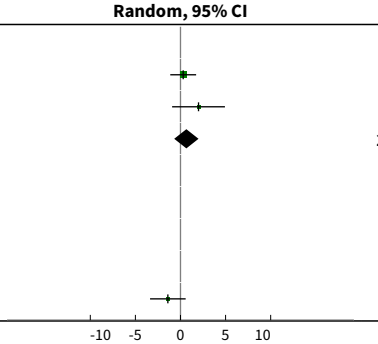
Analysis 1.1. Comparison 1 Chest physiotherapy compared with no chest physiotherapy, Outcome 1 Mortality.

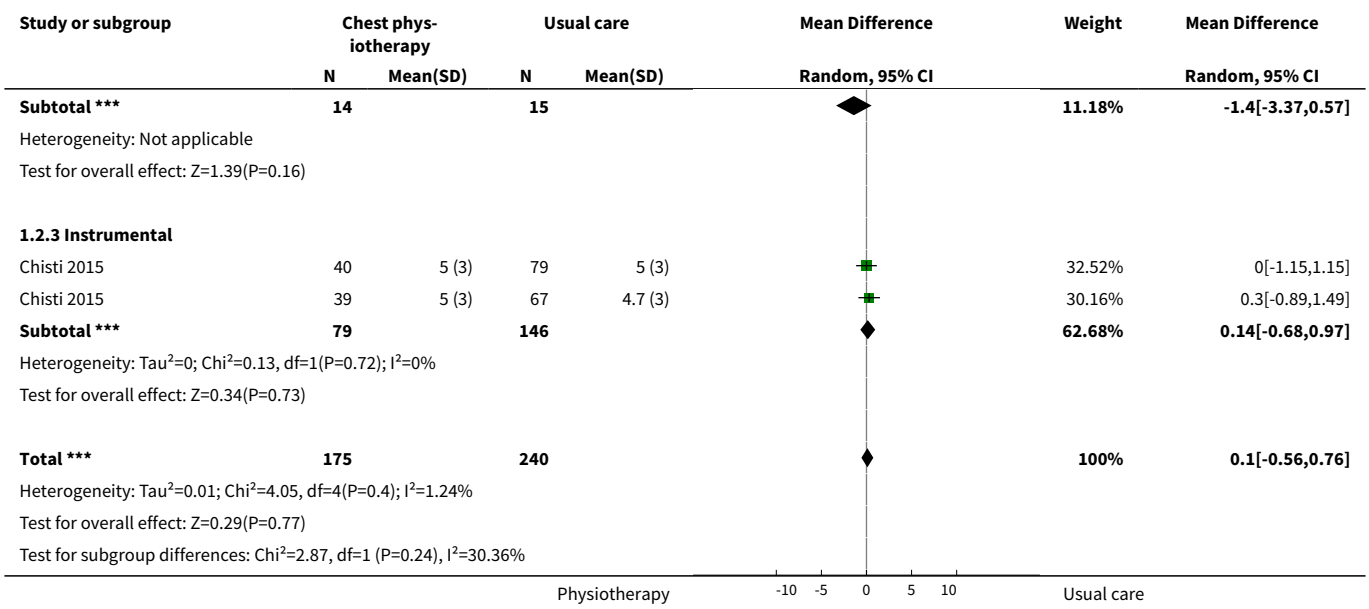
Study or subgroup	Chest physiotherapy n/N	Usual care n/N	Risk Ratio M-H, Random, 95% CI	Weight	Risk Ratio M-H, Random, 95% CI
Chisti 2015	3/79	20/146		100%	0.28[0.08,0.9]
Corten 2017a	0/14	0/15			Not estimable
Lukrafka 2012	0/35	0/37			Not estimable
Total (95% CI)	**128**	**198**		**100%**	**0.28[0.08,0.9]**
Total events: 3 (Chest physiotherapy), 20 (Usual care)					
Heterogeneity: Not applicable					
Test for overall effect: Z=2.13(P=0.03)					



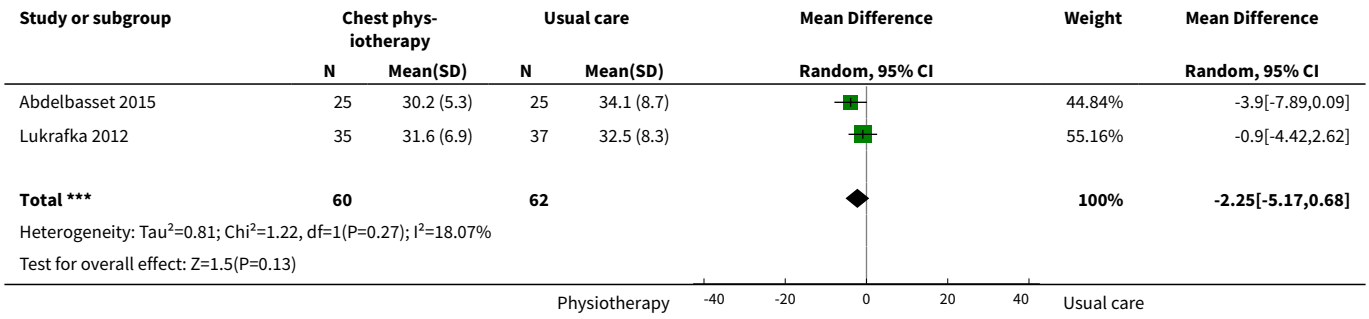
Analysis 1.2. Comparison 1 Chest physiotherapy compared with no chest physiotherapy, Outcome 2 Duration of hospital stay.

Study or subgroup	Chest physiotherapy N	Chest physiotherapy Mean(SD)	Usual care N	Usual care Mean(SD)	Mean Difference Random, 95% CI	Weight	Mean Difference Random, 95% CI
1.2.1 Conventional							
Paludo 2008	47	6.3 (3.8)	42	6 (3.1)		21.04%	0.3[-1.13,1.73]
Lukrafka 2012	35	8 (8.4)	37	6 (2.7)		5.1%	2[-0.93,4.93]
Subtotal ***	**82**		**79**			**26.14%**	**0.65[-0.7,2]**
Heterogeneity: Tau^2=0.06; Chi^2=1.04, df=1(P=0.31); I^2=4.3%							
Test for overall effect: Z=0.95(P=0.34)							
1.2.2 Modern							
Corten 2017a	14	7.3 (1.6)	15	8.7 (3.5)		11.18%	-1.4[-3.37,0.57]

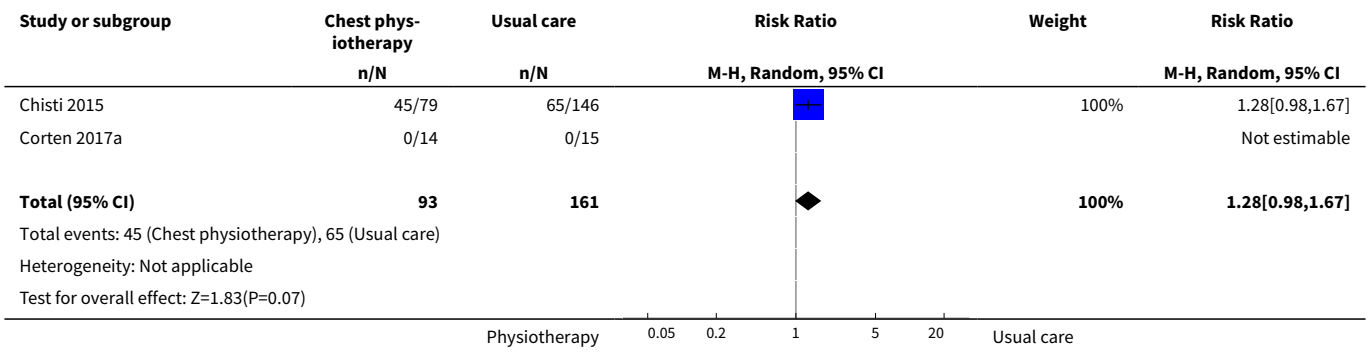




Analysis 1.3. Comparison 1 Chest physiotherapy compared with no chest physiotherapy, Outcome 3 Time to clinical resolution (respiratory rate).



Analysis 1.4. Comparison 1 Chest physiotherapy compared with no chest physiotherapy, Outcome 4 Adverse events.



APPENDICES

Appendix 1. Descriptions of chest physiotherapy techniques

Conventional physiotherapy

- Postural drainage involves positioning of the child with the assistance of gravity to mobilise secretions towards the main bronchus (Britto 2014).
- Vibration. In this technique, a rapid vibratory impulse is transmitted through the chest wall from the flattened hands of the therapist by isometric alternate contraction of forearm flexor and extensor muscles, to loosen and dislodge the airway secretions (Britto 2014).
- Percussion. The therapist uses a single hand or both cupped hands or three fingers with the middle finger tented, or a facemask with the port either covered or occluded by a finger, and strikes repeatedly at a rate of three per second over the part of the bronchopulmonary segment that needs to be drained (Britto 2014).
- Huffing. Fast expiration at high volume by the patient (Britto 2014).
- Coughing. Child is requested to cough. In unco-operative or small children, tracheal stimulation or tickling can be performed by placing index finger or thumb on the anterior side of the neck against trachea just above sternal notch with gentle but firm inward pressure in a circular pattern as the child begins to exhale (Britto 2014).
- Thoracic squeezing. This method stimulates the normal cough mechanism through elevation of intrathoracic pressure. This technique, which does not require any special equipment, is used exclusively for the thorax. The hands are placed on the lower third of the thorax. The therapist then applies pressure to increase the forced expiratory volume (FEV) by 30%. It is not necessary to disconnect the patient from the ventilation machine during treatment, which decreases episodes of hypoxaemia and the use of high fraction of inspired oxygen (FiO_2) (Guimaraes 2014; Yousefnia-Darzi 2016).

Modern techniques

- Forced expiratory technique. The recipient takes a diaphragmatic inspiration to medium volume, relaxing the scapulohumeral region, with the mouth and glottis open (Britto 2014).
- Active cycle of breathing technique. The recipient may be positioned supine, prone, lateral, or sitting and helped by the physiotherapist or perform this independently. It consists of the following phases.
  - Breathing control. The recipient performs inhalations and exhalations at current volume level, relaxing the upper thoracic region and breathing quietly using the lower chest.
  - Exercise chest expansion. This approach consists of deep-breathing exercises performed as slow nasal breathing at inspiratory reserve volume level, followed by a two- to three-second postinspiratory pause, and ending with oral expiration at functional residual capacity level.
  - Forced expiration technique. The recipient intakes diaphragmatic inspiration to medium volume, relaxing the scapulohumeral region, with the mouth and glottis open (Alexander 2017; Britto 2014).
- Autogenic drainage. This is a three-phase breathing technique using high expiratory flow rates and variable lung volumes to unstick, collect, and evacuate secretions. The recipient is placed sitting, back straight, and head slightly hyperextended, hands resting on the upper left and right chest (Alexander 2017; Britto 2014). The recipient first breathes at a low lung volume to unstick secretions in the peripheral airways, then at mid-volume to collect secretions in the central airways, and finally breathes at high volume to clear secretions from the lungs. Autogenic drainage is potentially advantageous because it improves independency. No equipment is needed, and it is applicable in different settings and in daily life (Corten 2017b). The three phases of autogenic drainage are as follows.
  - Displacement: starts with a slow and forced oral expiration, recruiting a percentage of expiratory reserve volume, and then carrying inspiration to low volume, recruiting percentages of tidal volume followed by a two- to three-second postinspiratory pause. This is followed by a slow oral exhalation recruiting a percentage of expiratory reserve volume.
  - Collection: nasal inspiration to medium volume, recruiting a larger percentage of tidal volume, followed by a two- to three-second postinspiratory pause. This is followed by a slow oral exhalation recruiting a percentage of expiratory reserve volume.
  - Elimination: nasal inspiration to high volume recruiting tidal volume and a percentage of inspiratory reserve volume, followed by a two- to three-second postinspiratory pause, leading to oral expiration at the level of tidal volume. The forced expiration technique is performed to high volumes.
- Assisted autogenic drainage. This is a modified form of autogenic drainage, used for babies and young children because it does not require active participation. The physiotherapist influences the level of breathing without the child consciously influencing the level of breathing (Corten 2017b).
- Slow and prolonged expiration. This is an entirely passive technique used when the age of a young child makes them unable to co-operate. The child is positioned supine. The therapist places one hand on the child's chest and the other on the abdomen. At the end of a spontaneous expiration, pressure is applied to the chest caudally and on the abdomen in a cephalic orientation. The pressure is maintained for two to three respiratory cycles. No pressure is exerted during the first part of expiration (Postiaux 1997).
- Increased expiratory flow. This technique should be performed during the expiratory time using pressure exerted by the physiotherapist's hand on the child's chest, with the child lying supine. The other hand remains static over the abdomen to prevent

the dissipation of pressure to the abdominal compartment, with the goal of deflation, the speed of which should be more than a spontaneous expiration (Postiaux 1992).

- Total slow expiration with the glottis open in a lateral posture. The child is placed in lateral position, and may be helped by the physiotherapist or perform independently. The child takes nasal inspiration at tidal volume level and slowly expires the breath with the open glottis at residual volume level (Postiaux 1997).
- Exercises of controlled inspiratory flow. This technique can be performed in two positions: posterolateral and anterolateral. In the first position, the child is placed in lateral position with the trunk and pelvis tilted slightly above perpendicular to the plane of support. In the second position, the child is placed in lateral position with the limb flexed and the upper hand on the occipital region to promote the elongation of the pectoral musculature. In both placements, the child performs a slow, deep inspiration recruiting the inspiratory reserve volume, then a two- to three-second postinspiratory pause, followed by oral expiration at functional residual capacity level (Postiaux 2000).

Instrumental techniques

- Positive expiratory pressure mask provides resistance to expiration through a mouthpiece or facemask, followed by forced expirations. This treatment must be carried out in a sitting position: the child inhales and exhales through the mask 15 times (approximately two minutes). The inhalation is at tidal volume, and the expiration is slightly active against the mask. The child then removes the mask and performs two or three forced expirations followed by a cough to clear secretions that are mobilised to the central airways. This procedure is followed by a one- to two-minute period of relaxed, controlled breathing (Alexander 2017; Britto 2014).
- Continuous positive airway pressure (CPAP) is generated by exhalation against a constant opening pressure; this produces positive end-expiratory pressure (PEEP). Continuous positive airway pressure can also be delivered by commercially available pressure drivers. These generally require tightly fitting nasal prongs or a CPAP facemask (Duke 2014).
- Bubble CPAP consists of an interface (nasal cannula), inspiratory tubing, and expiratory tubing immersed in an underwater bottle system. The child breathes spontaneously with positive pressure air flow, during both inspiration and expiration. Continuous positive airway pressure is thus maintained throughout the breathing cycle (Figueroa 2017). Bubble CPAP requires use of an adjustable flow generator, a pressure-regulator, and an interface. The gas flow rate required to generate CPAP is usually 5 to 10 L/min. This alone can generate CPAP, without additional oxygen (FiO_2 = 0.21). A pressure control tube submerged in a bottle of water controls end-expiratory pressure (Kawaza 2014; WHO 2016).
- Flutter. This is a pipe-shaped device that creates oscillation and positive pressure on expiration that is used in conjunction with forced expirations. The child performs a nasal inhalation, followed by an inspiratory pause lasting two to three seconds. Oral exhalation must be fast enough to move the ball. The sequence should be repeated for 10 to 15 breaths (Alexander 2017; Britto 2014).
- Incentive spirometer. This is referred to as sustained maximal inspiration and is accomplished by using a device that provides feedback when the recipient inhales at a predetermined flow or volume and sustains the inflation for at least five seconds (Restrepo 2011).

Appendix 2. MEDLINE (Ovid) search strategy

1 exp Pneumonia/
2 pneumon*.tw.
3 (bronchopneumon* or pleuropneumon*).tw.
4 (cap or hap or vap).tw.
5 ((lung* or pulmonary or pleur*) adj2 (infect* or inflam*)).tw.
6 empyema, pleural/ or pleural effusion/
7 (pleural adj3 (empyema or effusion*)).tw.
8 exp Pleurisy/
9 pleurisy.tw.
10 Respiratory Tract Infections/
11 (lower respiratory tract infection* or lower respiratory infection* or lrti).tw.
12 or/1-11
13 exp Physical Therapy Modalities/
14 (physiotherap* or physical therap* or physical treatment*).tw.
15 exp Respiratory Therapy/
16 exp Positive-Pressure Respiration/
17 Breathing Exercises/
18 Vibration/
19 (patient* adj3 (postur* or position*)).tw.
20 (body adj3 (postur* or position* or lateral)).tw.
21 (oscillat* or vibrat* or percuss* or huff*).tw.
22 ((chest or thora*) adj3 (clap* or shak* or compress*)).tw.
23 (cough* adj2 (directed or maneuver* or manoeuver* or techniqu*)).tw.
24 positive pressure ventilation*.tw.
25 positive expiratory pressure*.tw.
26 electrostimulat*.tw.

27 massag*.tw.
28 ((respirat* or ventilat*) adj2 muscle train*).tw.
29 ((postur* or autogenic) adj2 drain*).tw.
30 (breath* adj2 (control* or techni* or train* or exercis* or "active cycle")).tw.
31 ((forced or slow or prolonged or increas* or control*) adj2 (exhal* or expir*)).tw.
32 flutter.tw.
33 (incentive adj2 (inspiromet* or spiromet*)).tw.
34 eltgol.tw.
35 or/13-34
36 12 and 35

Appendix 3. Embase (Elsevier) search strategy

#36 #11 AND #35 15056
#35 #12 OR #13 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 250196
#34 eltgol:ab,ti 4
#33 (incentive NEAR/2 (inspiromet* OR spiromet*)):ab,ti 209
#32 flutter:ab,ti 6494
#31 ((forced OR slow OR prolonged OR increas* OR control*) NEAR/2 (exhal* OR inhal*)):ab,ti 2516
#30 (breath* NEAR/2 (control* OR techni* OR train* OR exercis* OR 'active cycle')):ab,ti 4591
#29 ((postur* OR autogenic) NEAR/2 drain*):ab,ti 309
#28 ((respirat* OR ventilat*) NEAR/2 ('muscle train' OR 'muscle training')):ab,ti 222
#27 massag*:ab,ti 5850
#26 electrostimulat*:ab,ti 2042
#25 'positive pressure ventilation':ab,ti OR 'postive expiratory pressure':ab,ti 4009
#24 (cough* NEAR/2 (directed OR maneuver* OR manoeuver* OR techniqu*)):ab,ti169
#23 ((chest OR thora*) NEAR/3 (clap* OR shak* OR compress*)):ab,ti 3291
#22 oscillat*:ab,ti OR vibrat*:ab,ti OR percuss*:ab,ti OR huff*:ab,ti 69253
#21 (body NEAR/3 (postur* OR positon* OR lateral)):ab,ti 2919
#20 (patient* NEAR/3 (postur* OR position*)):ab,ti 11130
#19 'vibration'/de 11265
#18 'breathing exercise'/de 2748
#17 'artificial ventilation'/exp 85889
#16 'oxygen therapy'/de 13072
#15 'extracorporeal oxygenation'/de 6897
#14 'postural drainage'/de 474
#13 physiotherap*:ab,ti OR 'physical therapy':ab,ti OR 'physical therapies':ab,ti OR 'physical treatment':ab,ti OR 'physical treatments':ab,ti 26544
#12 'physiotherapy'/exp 34808
#11 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 261137
#10 'lower respiratory tract infection':ab,ti OR 'lower respiratory tract infections':ab,ti OR 'lower respiratory infection':ab,ti OR 'lower respiratory infections':ab,ti OR lrti:ab,ti 5195
#9 'lower respiratory tract infection'/de 5969
#8 pleurisy:ab,ti 2255
#7 'pleurisy'/de OR 'exudative pleurisy'/de 4261
#6 'pleura effusion'/de OR 'pleura empyema'/de 25867
#5 ((lung* OR pulmonary OR pleur*) NEAR/2 (infect* OR inflam*)):ab,ti 25127
#4 cap:ab,ti OR hap:ab,ti OR vap:ab,ti 30610
#3 bronchopneumon*:ab,ti OR pleuropneumon*:ab,ti 3654
#2 pneumon*:ab,ti 119018
#1 'pneumonia'/exp 138579

Appendix 4. CINAHL (EBSCO) search strategy

S58 S35 AND S48 AND S57 71
S57 S49 OR S50 OR S51 OR S52 OR S53 OR S54 OR S55 OR S56 178,200
S56 (MH "Quantitative Studies") 8,230
S55 (MH "Placebos") 6,531
S54 TI placebo* OR AB placebo* 19,643
S53 TI random* OR AB random* 97,503
S52 TI ((singl* or doubl* or trebl* or tripl*) W1 (blind* or mask*)) OR AB ((singl* or doubl* or trebl* or tripl*) W1 (blind* or mask*)) 14,307
S51 TI clinic* W1 trial* OR AB clinic* W1 trial* 27,056

S50 PT clinical trial 51,858
S49 (MH "Clinical Trials+") 109,939
S48 S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44 OR S45 OR S46 OR S47 490,359
S47 TI (nursery school* or kindergar* or primary school* or secondary school* or elementary school* or high school* or highschool*) OR AB (nursery school* or kindergar* or primary school* or secondary school* or elementary school* or high school* or highschool*) 12,361
S46 (MH "Schools+") 30,483
S45 TI (pediatric* or paediatric*) OR AB (pediatric* or paediatric*) 40,374
S44 (MH "Pediatrics+") 6,021
S43 TI (minor* or juvenile* or pubert* or pubescen*) OR AB (minor* or juvenile* or pubert* or pubescen*) 24,422
S42 (MH "Puberty") 974
S41 TI (adoles* or teen* or boy* or girl*) OR AB (adoles* or teen* or boy* or girl*) 57,128
S40 (MH "Adolescence+") 179,705
S39 (child* or schoolchild* or school age* or preschool* or kid or kids or toddler*) OR (child* or schoolchild* or school age* or preschool* or kid or kids or toddler*) 305,552
S38 (MH "Child+") 266,981
S37 TI (infant* or infancy or newborn* or baby* or babies or neonat* or preterm* or prematur* or postmatur*) OR AB (infant* or infancy or newborn* or baby* or babies or neonat* or preterm* or prematur* or
postmatur*) 72,042
S36 (MH "Infant+") 107,884
S35 S11 AND S34 1,729
S34 S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 100,769
S33 TI eltgol OR AB eltgol 2
S32 TI (incentive N2 (inspiromet* or spiromet*)) OR AB (incentive N2 (inspiromet* or spiromet*)) 98
S31 TI flutter OR AB flutter 1,055
S30 TI ((forced or slow or prolonged or increas* or control*) N2 (exhal or expir*)) OR AB ((forced or slow or prolonged or increas* or control*) N2 (exhal or expir*)) 1,533
S29 TI (breath* N2 (control* or techni* or train* or exercis* or "active cycle")) OR AB (breath* N2 (control* or techni* or train* or exercis* or "active cycle")) 845
S28 TI ((postur* or autogenic) N2 drain*) OR AB ((postur* or autogenic) N2 drain*) 85
S27 TI ((respirat* or ventilat*) N2 muscle train*) OR AB ((respirat* or ventilat*) N2 muscle train*) 117
S26 TI massag* OR AB massag* 3,972
S25 TI electrostimulat* OR AB electrostimulat* 157
S24 TI positive expiratory pressur* OR AB positive expiratory pressur*712
S23 TI positive pressure ventilation* OR AB positive pressure ventilation* 954
S22 TI (cough* N2 (directed or maneuver* or manoeuver* or techniqu*)) OR AB (cough* N2 (directed or maneuver* or manoeuver* or techniqu*)) 57
S21 TI ((chest or thora*) N3 (clap* or shak* or compress*)) OR AB ((chest or thora*) N3 (clap* or shak* or compress*)) 533
S20 TI (oscillat* or vibrat* or percuss* or huff*) OR AB (oscillat* or vibrat* or percuss* or huff*) 3,324
S19 TI (body N3 (postur* or position* or lateral)) OR AB (body N3 (postur* or position* or lateral)) 904
S18 TI (patient* N3 (postur* or position*)) OR AB (patient* N3 (postur* or position*)) 2,168
S17 (MH "Vibration") 1,386
S16 (MH "Breathing Exercises+") 971
S15 (MH "Positive Pressure Ventilation+") 4,266
S14 (MH "Respiratory Therapy+") 19,474
S13 TI (physiotherap* or physical therap* or physical treatment*) OR AB (physiotherap* or physical therap* or physical treatment*) 20,748
S12 (MH "Physical Therapy+") 61,365
S11 S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 19,864
S10 TI (lower respiratory tract infection* or lower respiratory infection* or lrti) OR AB (lower respiratory tract infection* or lower respiratory infection* or lrti) 597
S9 (MH "Respiratory Tract Infections") 3,194
S8 TI (pleural N3 (empyema or effusion*)) OR AB (pleural N3 (empyema or effusion*)) 929
S7 TI pleurisy OR AB pleurisy 65
S6 (MH "Pleurisy") 81
S5 (MH "Empyema") OR (MH "Pleural Effusion") 1,091
S4 TI ((lung* or pulmonary or pleur*) N2 (infect* or inflam*)) OR AB ((lung* or pulmonary or pleur*) N2 (infect* or inflam*)) 1,577
S3 TI (cap or hap or vap) OR AB (cap or hap or vap) 2,251
S2 TI (pneumon* or bronchopneumon* or pleuropneumon*) OR AB (pneumon* or bronchopneumon* or pleuropneumon*) 9,935
S1 (MH "Pneumonia+") 8,666

Appendix 5. LILACS (BIREME) search strategy

(MH:pneumonia OR pneumon$ OR Neumonía OR MH:C08.381.677$ OR MH:C08.730.610$ OR "Inflamación Experimental del Pulmón" OR "Inflamación del Pulmón" OR "Neumonía Lobar" OR Neumonitis OR "Inflamación Pulmonar" OR Pneumonía OR Pulmonía OR "Inflamação Experimental dos Pulmões" OR "Inflamação do Pulmão" OR "Pneumonia Lobar" OR Pneumonite OR "Inflamação Pulmonar" OR Pulmonia OR Bronchopneumonia OR Bronconeumonía OR Pleuropneumonia OR Pleuroneumonía OR MH:"Empyema, Pleural" OR "Empiema Pleural" OR "Pleural Effusion" OR "Derrame Pleural" OR MH:Pleurisy OR Pleuresia OR Pleurisia OR pleurisy OR "pleural effusion" OR MH:"Respiratory Tract Infections" OR "Infecciones del Sistema Respiratorio" OR "Infecções Respiratórias" OR " lower respiratory tract infection" OR "lower respiratory tract infections" OR "lower respiratory infection" OR "lower respiratory infections" or lrti OR "Infecciones de las Vías Respiratorias" OR "Infecciones del Aparato Respiratorio" OR "Infecciones del Tracto Respiratorio" OR "Infecciones Respiratorias" OR "Infecções das Vias Respiratórias" OR "Infecções do Aparelho Respiratório" OR "Infecções do Sistema Respiratório" OR "Infecções do Trato Respiratório") AND (MH:"Physical Therapy Modalities" OR MH:E02.779$ OR "Modalidades de Fisioterapia" OR "Modalidades de Fisioterapia" OR physiotherap$ OR "physical therapy" OR "physical therapies" OR "physical treatment" OR "physical treatments" OR "Modalidades de Terapia Física" OR Fisioterapia OR "Técnicas Fisioterápicas" OR MH:"Respiratory Therapy" OR MH:E02.880$ OR "Terapia Respiratoria" OR "inhalation therapy" OR "Terapia de Inhalación" OR "Terapia por Inalação" OR MH:"Positive-Pressure Respiration" OR MH:E02.041.625.790$ OR MH:E02.880.820.790$ OR "Respiración con Presión Positiva" OR "Respiração com Pressão Positiva" OR MH:"Breathing Exercises" OR "Ejercicios Respiratorios" OR "Exercícios Respiratórios" OR "Respiratory Muscle Training" OR "Entrenamiento del Musculo Respiratorio" OR "Exercícios para os Músculos Respiratórios" OR MH:Vibration OR Vibración OR Vibração OR oscillat$ OR vibrat$ OR percuss$ OR huff$ OR coughing Or "directed cough" OR "cough technique" OR "patient posture" OR "body posture" OR "patient position" OR "patient positioning" OR "body position" OR "lateral position" OR "lateral posture" OR ELTGOL OR "forced expiration technique" OR "active cycle of breathing" OR "slow expiration" OR "prolonged expiration" OR ELPr OR "increased expiratory flow" OR AFE OR "inspiratory controlled flow" OR EDIC OR "positive expiratory pressure" OR PEP OR flutter OR electrostimulat$ OR massag* OR "postural drainage")

Appendix 6. Web of Science (Thomson Reuters) search strategy

# 7	76	#6 AND #5 *Databases=SCI-EXPANDED, CPCI-S Timespan=All Years* *Lemmatization=On*
# 6	1,306,314	Topic=(random* or placebo* or crossover* or "cross over" or allocat* or ((singl* or doubl*) NEAR/1 (blind* or mask*))) OR Title=(trial) *Databases=SCI-EXPANDED, CPCI-S Timespan=All Years* *Lemmatization=On*
# 5	347	#4 AND #3 *Databases=SCI-EXPANDED, CPCI-S Timespan=All Years* *Lemmatization=On*
# 4	1,748,376	Topic=(infant* or infancy or newborn* or baby* or babies or neonat* or preterm* or prematur* or postmatur* or child* or schoolchild* or "school age*" or preschool* or kid or kids or toddler* or adoles* or teen* or boy* or girl* or minor* or juvenile* or pubert* or pubescen* or pediatric* or paediatric* or kindergar* or highschool* or (school* NEAR/1 (nursery or primary or secondary or elementary or high))) *Databases=SCI-EXPANDED, CPCI-S Timespan=All Years* *Lemmatization=On*
# 3	1,590	#2 AND #1 *Databases=SCI-EXPANDED, CPCI-S Timespan=All Years* *Lemmatization=On*

(Continued)

# 2	422,588	Topic=(physiotherap* or (physical NEAR/1 (treatment* or therap*)) or "respiratory therapy" or "positive pressure respiration" or "positive pressure ventilation" or (patient* NEAR/3 (posture or position*)) or (body NEAR/3 (postur* or position* or lateral)) or oscillat* or vibrar* or percuss* or huff* or (cough* NEAR/2 (directed or maneuver* or manoeuver* or techni*)) or "positive expiratory pressure" or electrostimulat* or massag* or ((respirat* or ventilat*) NEAR/2 "muscle training") or ((postur* or autogenic) NEAR/2 drain*) or (breath* NEAR/2 (control* or techni* or train* or exercis* or "active cycle")) or ((forced or slow or prolonged or increas* or control*) NEAR/2 (exhal* or expir)) or flutter or (incentive NEAR/2 (inspiromet* or spiromet*)) or eltgol) *Databases=SCI-EXPANDED, CPCI-S Timespan=All Years* *Lemmatization=On*
# 1	163,229	Topic=(pneumon* or bronchopneumon* or pleuropneumon* or pleurisy or ((lung* or pulmonary or pleur*) NEAR/2 (infect* or inflam*)) or (pleural NEAR/2 (empyema or effusion*)) or "lower respiratory tract infection" or "lower respiratory tract infections" or "lower respiratory infection" or "lower respiratory infections" or lrti) *Databases=SCI-EXPANDED, CPCI-S Timespan=All Years* *Lemmatization=On*

Appendix 7. PEDro (Physiotherapy Evidence Database) search strategy

Pneumonia in title abstract field
Paediatrics in subdivision field
Clinical trials in methods field

Appendix 8. Details of previous searches

For the 2013 version of the review (Chaves 2013), we searched the Cochrane Central Register of Controlled Trials (CENTRAL) 2013, Issue 4, part of the Cochrane Library (www.thecochranelibrary.com) (accessed 31 May 2013), which includes the Cochrane Acute Respiratory Infections Group Specialised Register, MEDLINE (1946 to May week 4, 2013), Embase (1974 to May 2013), CINAHL (Cumulative Index to Nursing and Allied Health Literature) (1981 to May 2013), LILACS (Latin American and Caribbean Health Science Information database) (1982 to May 2013), Web of Science (1950 to May 2013), and PEDro (Physiotherapy Evidence Database) (1950 to May 2013).

WHAT'S NEW

Date	Event	Description
18 September 2019	Amended	We amended the 'mortality' outcome data analysis. We performed a subgroup analysis by techniques (conventional, modern, and instrumental) for the 'duration of hospital stay' outcome. In both adjustments no change was observed in the results of the analysis. Therefore, our conclusions remain unchanged. In the Methods section ('measures of treatment effect') we have explained how the mean and standard deviation were calculated.

HISTORY

Protocol first published: Issue 12, 2012
Review first published: Issue 9, 2013

Date	Event	Description
22 February 2018	New citation required but conclusions have not changed	Authorship of this review update has changed. Thayla A Santino and Patricia Angelica MS Nogueira are new coauthors of this review.
22 February 2018	New search has been performed	Searches updated. We included three new trials (Abdelbasset 2015; Chisti 2015; Corten 2017a), and excluded six new trials (Brambilla 2014; Ivanov 2015; Jayashree 2016; Kole 2014; Kuyrukluyildiz 2016; Leelarungrayub 2016). Our conclusions remain unchanged.

CONTRIBUTIONS OF AUTHORS

Gabriela Chaves (GC): ran the search update, 'Risk of bias' assessment, entered data into Review Manager 5, carried out and interpreted the analysis, and drafted the final review.
Diana Freitas (DF): 'Risk of bias' assessment, entered data into Review Manager 5, carried out and interpreted the analysis, drafted the final review, and checked grammar.
Thayla Santino (TS): selected the studies, entered data into Review Manager 5, and drafted the final review.
Patricia Nogueira (PN): selected the studies, extracted data from studies to resolve differences when necessary, 'Risk of bias' assessment to resolve differences when necessary, and drafted the final review.
Guilherme Fregonezi (GF): extracted data.
Karla Mendonça (KM): co-ordinated the review, selected the studies to resolve differences when necessary, extracted data, interpreted the analysis, and drafted the final review.

DECLARATIONS OF INTEREST

Gabriela SS Chaves: None known.
Diana A Freitas: None known.
Thayla A Santino: None known.
Patricia Angelica MS Nogueira: None known.
Guilherme AF Fregonezi: None known.
Karla MPP Mendonça: None known.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

Three new authors were included for the 2018 update. Although the protocol indicated that we planned to include cross-over trials, we decided to exclude cross-over studies because the study design is not appropriate for the population. Regarding the primary outcome measure 'time to clinical resolution (days)', we have included respiratory rate as a parameter to assess the increase of respiratory work, such as chest indrawing, nasal flaring, and tachypnoea. We included a 'Summary of findings' table and GRADE assessment of evidence quality.

INDEX TERMS

Medical Subject Headings (MeSH)

Continuous Positive Airway Pressure [methods] [mortality]; Drainage; Length of Stay [statistics & numerical data]; Oxygen [blood]; Pneumonia [mortality] [*therapy]; Positive-Pressure Respiration [methods]; Randomized Controlled Trials as Topic; Respiratory Rate; Respiratory Therapy [adverse effects] [*methods] [mortality]

MeSH check words

Child; Child, Preschool; Female; Humans; Infant; Infant, Newborn; Male